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BYTE®

the small systems journal

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ROBERT '79 TINNEY

DOMESTICATED COMPUTERS

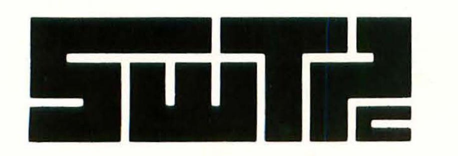
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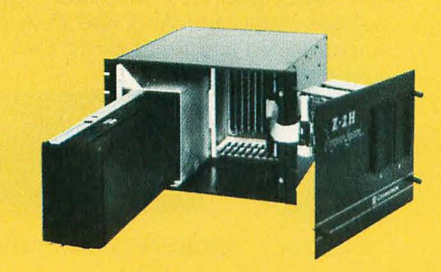
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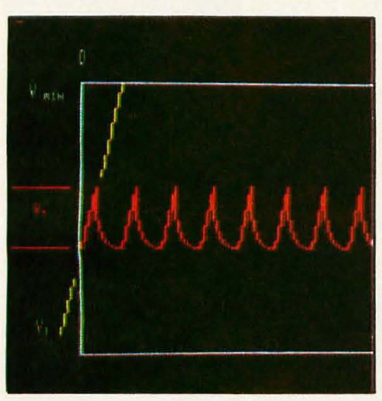
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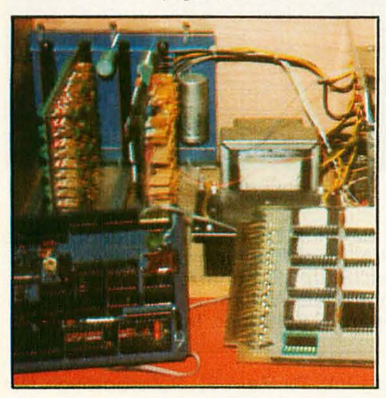
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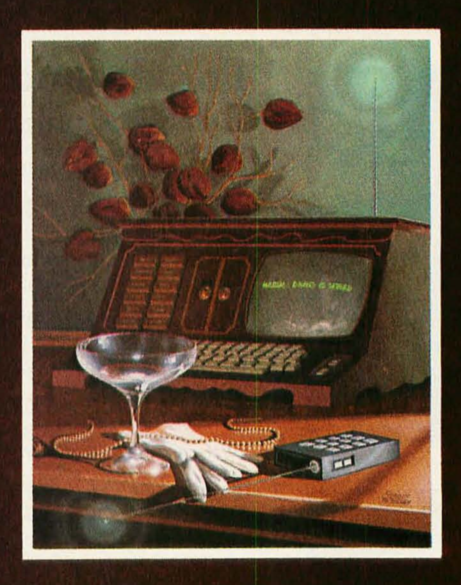


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NOTICE:
The 1980 Priority One Electronics Engineering Selection Guide begins on page 80-C1 in this issue



ON THE COVER

The theme of this issue's cover illustration is "the domesticated computer." Robert Tinney has taken the idea of the remote controlled appliances suggested by Steve Ciarcia's article on page 28 and combined it with some imaginative cabinetry in a household setting. In the process, Robert used his artistic license to employ radio imagery with antennae and aetheric airbrushing as an alternative to ultrasonic techniques described by Steve. Either way, practical means of safely controlling 110V appliances from the computer with total electrical isolation now exist — both for the homebrewer and as practical products advertised in this issue.

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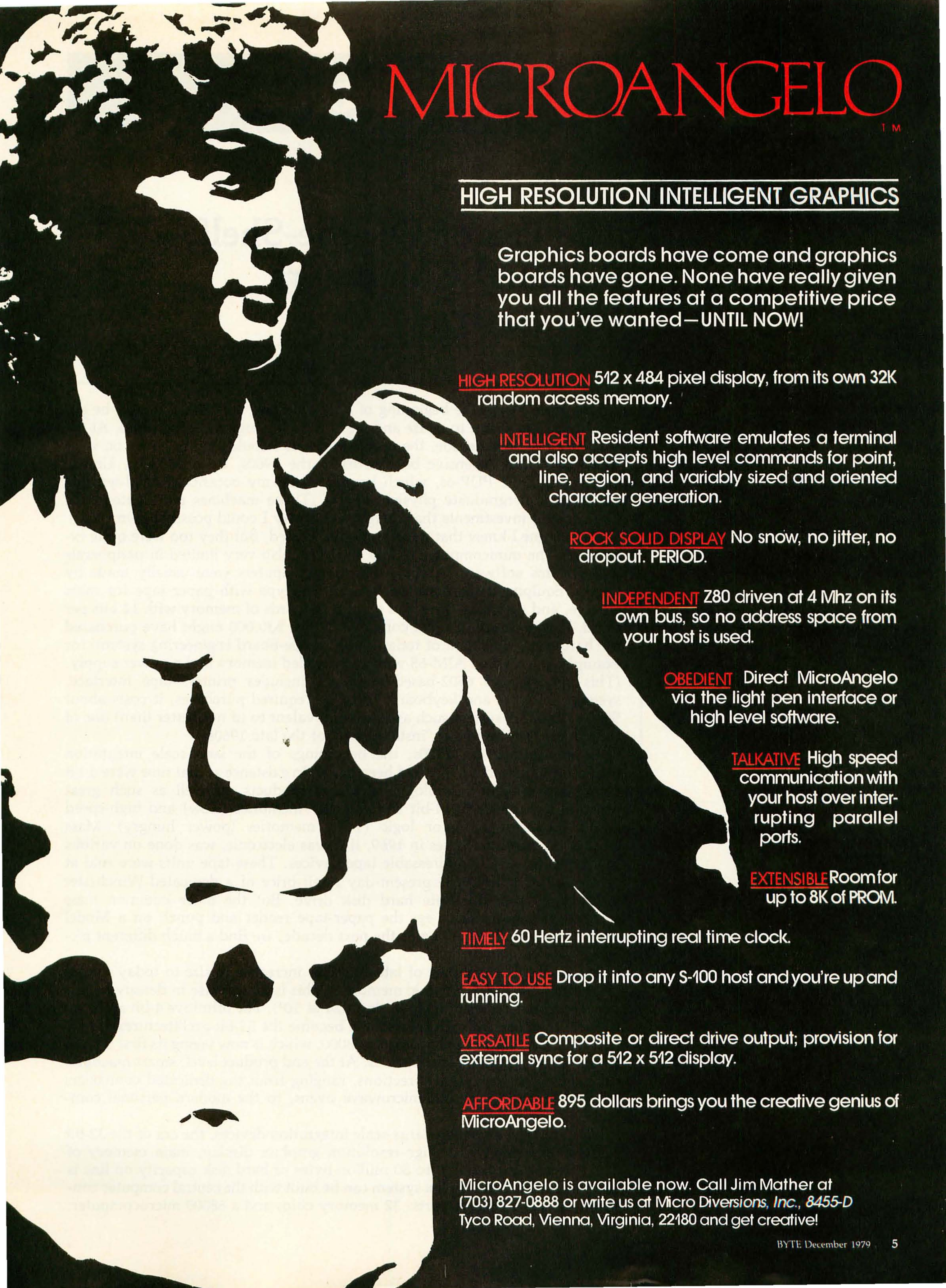
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Editorial

The Era of Off-the-Shelf Personal Computers Has Arrived

Carl Helmers

This issue marks the beginning of a new decade: the 1980s. It may be appropriate at this time to pause and see how technology has progressed. At the turn of a previous decade, the only computers I could get my hands on were those large and expensive behemoths of the 1960s, the IBM 360s, Univac 1108s, and DEC PDP-6s, which I used during my occasional employments while an undergraduate physics student. Those machines represented such large capital investments that there was no way I could possibly own one.

At the time I knew that minicomputers existed. But they too were quite expensive. The minicomputer of late 1969 was also very limited in peripherals and systems software. At that time minicomputers were usually made by Digital Equipment Corporation, used a Teletype with paper tape for mass storage, and they may have had all of 8 K words of memory with 12 bits per word. It was an era in small computers when $30,000 might have purchased the hardware equivalent of today's $500 single-board engineering system; for example, a Rockwell AIM-65 with some added memory and a power supply. (This single-board 6502-based computer includes printer, tape interface, systems software and keyboard. With all required purchases, it costs about $500 to $600. A system such as this is equivalent to (if not better than) one of the typical minicomputer "installations" of the late 1960s.)

As we entered the 1970s, the beginnings of the large-scale integration microcomputer technology had been made. In existence at that time were 4-bit computers in high-technology calculator products, as well as such great accomplishments as 1024-bit shift register memories (slow) and high-speed 64-bit transistor-transistor logic (TTL) memories (power hungry). Mass storage on small machines in 1969, if it was electronic, was done on various randomly or serially addressable tape devices. These tape units were sold at prices comparable to the present-day retail price of a dedicated Winchester technology 10-million-byte hard disk drive. But the more common mass storage was mechanical, eg: the paper-tape reader and punch on a Model ASR-33 Teletype. As we enter the next decade, we find a much different picture.

The 64-bit memory part of late 1969 has increased in size to today's latest technology 64 K bit dynamic memories. This is an increase in density of just over 3 decimal orders of magnitude ($1024 \cong 10^3$). The primitive 4-bit architectures of then current calculators have become the 32-bit architectures of current machines such as the Motorola 68000, which is now seeing its first limited deliveries to prototype laboratories. At the end product level, smart machines have taken off in myriad directions, ranging from the dedicated controllers of computerized toys and microwave ovens, to the modern personal computer.

With the new extremely large-scale integration devices, the era of the 32-bit personal computer with high-resolution graphics display, main memory of 256 K bytes and from 10 to 50 million bytes of hard disk capacity on line is nearly here. In 1980, such a system can be built with the central computer consisting of just 33 major parts: 32 memory chips and a 68000 microcomputer.

Ancillaries, such as buffers and read-only memories, might double that count to 66. In a very approximate systems sense, the manufacturing cost of an electronic system is proportional to the number of parts involved. This is exclusive of intangibles like software and aesthetics. So the manufacturing cost of such a device two years from now will make *it* the typical personal computer.

But what of right now? Where would we stand if there were to be no technological improvements in off-the-shelf personal computers? What is the state of today's technology? I am going to describe some of the criteria that make up the design of a good modern personal computer system — and then I will make some comments about a particular system I just purchased and upon which I am creating this editorial. The fact that I have made a particular choice reflects the *necessity for choice* and not necessarily that other machines might not have served me as well. I will leave comments about this particular machine until later while I go into more details about what I see as the state of the art in small computers at the beginning of the 1980s.

The Personal Computer Circa 1980 . . .

As of this writing, October 1979, the state of the art in personal computing is such that the user is king. It is possible to enter a computer store and witness the operation of a typical modern system, try it out, then purchase one just like it to take home and use. The discriminating user must pay attention to a number of technical points relevant to the function of systems: areas of hardware, systems software, applications software, and plain old-fashioned idiosyncracies such as aesthetics and programming styles enter into a decision about which computer to purchase. But there is a core of minimum function which must be met in the contemporary small computer.

Starting this tour of function at the level of system design, what are the characteristics of the processor and memory required? First, remember the often overlooked point that the particular processor used is an arbitrary consideration within a broad range. This is especially so in an era when high-level languages and systems software can insulate the programmer from needless details of low-level code.

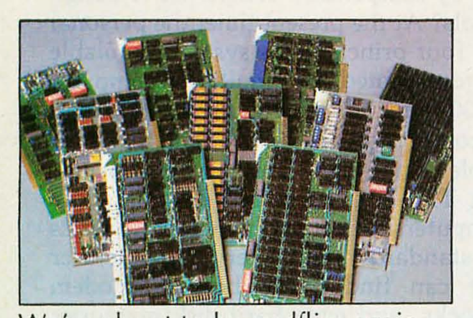
In present-day personal computers the processors which are typically used are 8-bit devices: 8080s, 6502s, Z80s, 8085s, 6800s, and 6809s. In raw performance statistics, all of these are comparable within a factor of 2 or 3 depending upon the benchmark chosen. Each has its own strengths and weaknesses. The basic limitation of present-era computers is the 8-bit bus, which cycles at only a several megahertz rate (a typical system memory access time is 200 to 500 nanoseconds). Transferring a byte at a time is often the most significant speed limitation.

Thus the processor choice is relatively unconstrained among the various off-the-shelf computers available today. What of memory? Whatever the processor, the more memory available, the better the system. I believe that the convenient and pleasurable use of the small computer as it exists today requires a bare minimum of 32 K (ie: 32,768) bytes. Of the computers I use regularly, two have 64 K bytes and one has 53 K bytes. The primary criterion for selecting memory technologies for a user of a

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(Or, when you're ready for IEEE S-100, will your computer be ready for you?)



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We call our new line Series II.™ And even if you don't need the full 24-bit address for up to 16 megabytes (!) of memory right now, they're something to think about. Because of all the performance, flexibility and economy they offer. Whether you're looking at a new mainframe, expanding your present one or upgrading your system with an eye to the future. (Series II boards are compatible with most existing S-100 systems and *all* IEEE S-100 Standard cards as other manufacturers get around to building them.)

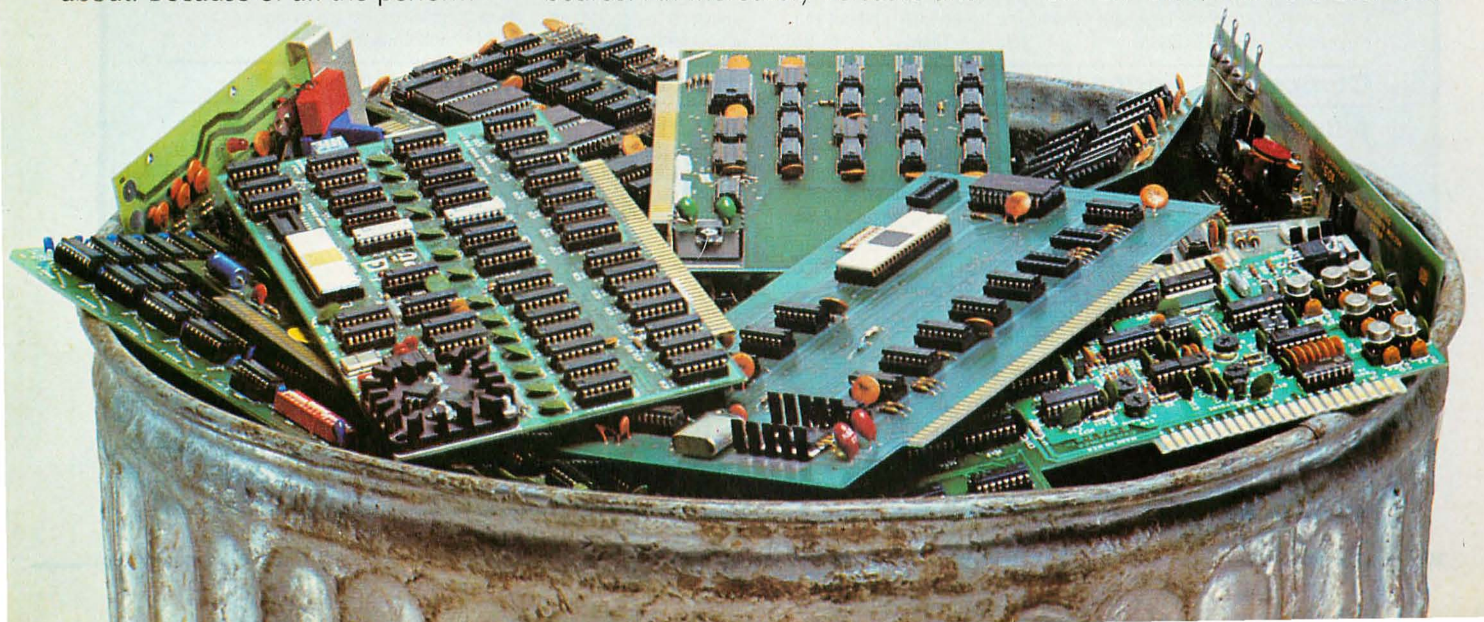
Consider some of the features: Reliable operation to 4MHz and beyond. Full compatibility with 8- and 16-bit CPUs, peripherals and other devices. *Eight* levels of prioritized interrupts. Up to 16 individually-addressable DMA devices, with IEEE Standard overlapped operation. User-selectable functions addressed by DIP-switch or jumpers, eliminating soldering. And that's just for openers.

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Whatever your needs, why dump your money into obsolete products labelled "IEEE timing compatible" or other words people use to make up for a lack of product. See the future now, at your Intersystems dealer or call/write for our new catalog. We'll tell you all about Series II and the new IEEE S-100 Bus we helped pioneer. Because it doesn't make sense to buy yesterday's products when tomorrow's are already here.

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modern computer is that it be in the system, competently engineered, and reliable. Engineering jargon terms like "static" versus "dynamic" are meaningless once a product has passed the design stage and becomes a reliable mass-produced product. The fact that nearly all mass-produced computers use dynamic memory is a statement about the costs of various semiconductor engineering technologies. When I buy a computer off the shelf, I care only about the quantity of main memory available for use as a resource.

In addition to the need for adequate main memory, the next question is, what of magnetic mass storage? At a bare minimum, the personal computer should have on the order of 500 K bytes of on-line storage, preferably in two or more drives. In today's technology, the most prevalent magnetic medium is the 5- or 8-inch floppy disk, with single-, double- or quad-density recording. Although recently introduced in personal computers, the hard disk technology based on drive products, from firms like Shugart, IMI and Micromation, is not nearly as prevalent as it will be in 1980 and beyond; the standard configuration for most small computers is two or more floppy disk drives as 1979 draws to a close.

At the level of user interfaces, the standard display hardware of a usable small computer is the 24 (or 25) line by 80-character video display. In some machines this is built in as a board in the system itself; on others it is provided in the form of a high-speed serial link (typically 19.2 kbps) to a video terminal. In either design, the terminal interface has a standard keyboard similar to a typewriter, and both upper and lowercase text are supported. In this era, when the marginal cost of a full upper and lowercase text capability is low compared to system cost, there is no excuse for perpetuating primitive computers' use of only uppercase text. Still remaining at a hardware level, it is necessary to have a hard copy device for most effective use of a small computer (or a large computer for that matter). Rare is the person who can remember all the details of a program without hard copy; and rare is the computer system with sufficient redundant displays so that multiple independent pages of text can be conveniently viewed simultaneously. In a personal computer at prices within reason today, hard copy is a necessity.

What about the options and their availability? Does the computer in question have a de facto standard bus design which is used by independent companies to design compatible peripherals? At the present time, the personal computer world has four principal bus systems available — two that are represented by multiple computer manufacturers (S-100 and SS-50), and two that are represented by one computer manufacturer and many independent compatible peripherals manufacturers (Apple II and Radio Shack TRS-80). These bus designs allow owners of small computers to mix and match peripherals beyond those of the standard variety every manufacturer provides. Thus we can find music boards, modem boards, real-time clocks, and even hard disk memories which plug into the bus definitions of one or more of the widely used de facto standards.

Going on to the issue of software and its specifications,

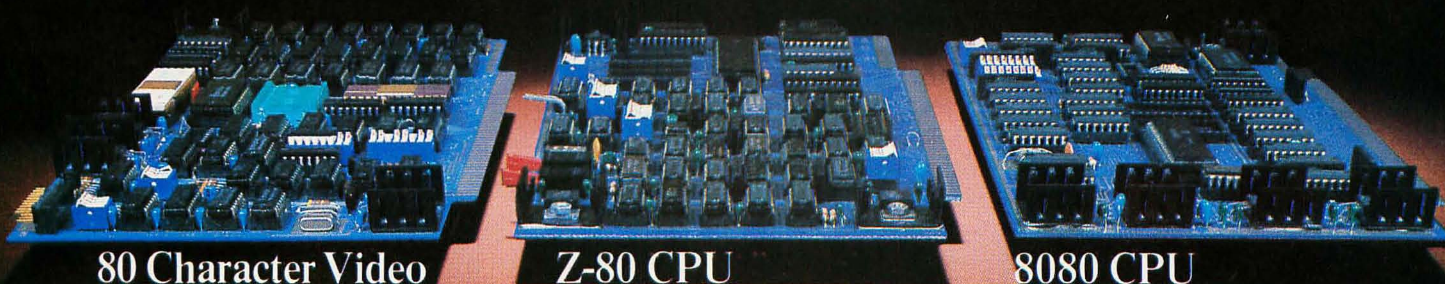
Text continued on page 93



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Circle 6 on inquiry card.

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80 Character Video

With 80 characters per line our VB3 is the perfect video interface for word processing. It produces a standard 80x24 display of upper and lower case characters or as much as 80x51 for a full page of text. The matrix for graphic display goes up to 160x204. And with optional EPROM, as many as 256 user programmed characters or symbols can be produced.

VB3 is memory mapped for rapid screen updating. But it occupies memory only when activated. So one or more VB3s can be located at the same address with a full 65K of memory still available to the user.

It generates both U.S. and European TV rates and meets the new IEEE S-100 standard. Other features include keyboard input, black on white or white on black, one level of grey, underline, strike thru, blinking char., blank-out char., and programmable cursor. Software includes a CP/M compatible driver and a powerful terminal simulator.

VB3 is available in several configurations. Retail prices start at $375 kit, $440 assembled.

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We spent over a year designing the CB2 to assure that it will be the most fully S-100 compatible Z-80 CPU on the market.

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It also features an optional 2K of 2708 EPROMs, power-on/reset vector jump, MWRITE, parallel input port with status and DIP switch addressing.

Retail price—$159 kit, $219 assembled.



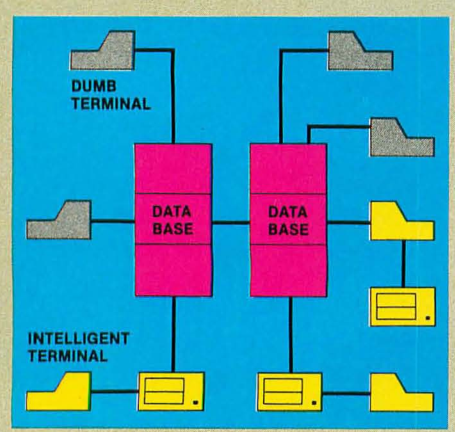
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Microcomputing comes of age.

Ohio Scientific's OS-65U Level 3 operating system software brings new networking and distributed processing capabilities to microprocessor based computer systems.



Until now, the only alternative for low cost multiple-user computer applications was time-shared systems. However, a serious drawback of microcomputer or mini-computer multi-user time-share systems is the fact that under heavy work loads they slow down to a crawl since the central processor time in such a system is shared by all of the users.

In a microprocessor based distributed processing system, using floppy based microcomputers as intelligent terminals (local systems) most of the work load is handled locally. Overall system performance does not degrade under heavy job loads. Each local system performs entry, editing and execution while utilizing the central data base for disk storage, printer output, and other shared resources.

For more demanding applications it is desirable to have several data bases, each with its own collection of local systems. Such an inter-connected set of data bases is called a network. Each data base and its local intelligent and dumb terminals is called a cluster.

Level III

OS-65U Level 3 now supports this advanced networking and distributed processing capability as well as conventional single user operation and time-sharing. Level 3 now supports local clusters of intelligent microcomputer systems as well as dumb terminals for the purpose of utilizing a central Winchester disk data base and other shared resources. The system also has full communications capability with other Level 3 data bases providing full network capability.

The system utilizes Ohio Scientific's low cost, ultra high performance computer systems throughout for intelligent terminals as well as data bases. This general systems configuration provides a cost/ performance ratio never before attained in this class of computer power.

Level 3 resides in each network data base. A subset system resides in each intelligent terminal. Each data base supports up to 16 intelligent systems and up to 16 dumb terminals. However, since dumb terminals can heavily load the system, they should be kept to a minimum. Level 3 also supports a real time clock, printer management, and other shared peripherals.

Data Base Requirements

Minimal requirements for a Level 3 network data base are a C3-C or C3-B computer system with 23 or 74 megabytes respectively, console terminal, 100K bytes RAM and a CA-10X 16 port I/O board for network and cluster communications.

Intelligent Terminal Requirements

Any Ohio Scientific 8" floppy based computer with 56K RAM and one data base communications port.

Connections

Intelligent terminals and networked data bases are connected by low-cost cabling. Each link can be up to 10,000 feet long at a transfer rate of 500K bits per second, and will cost typically 30¢ a foot (plus installation).

Syntax

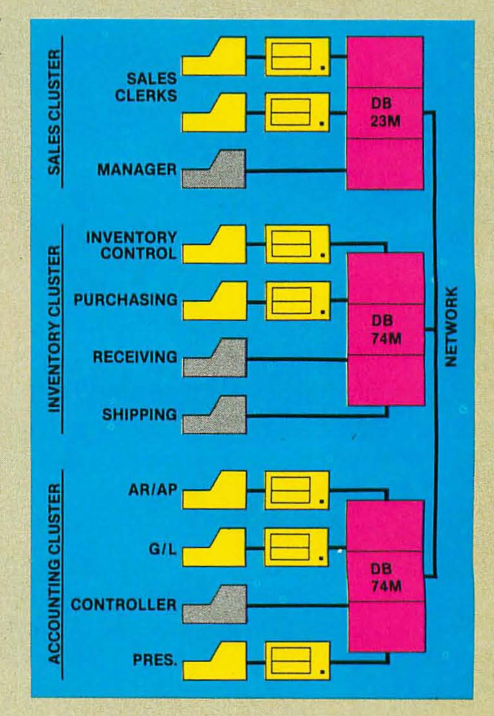
Existing OS-65U based software can be directly installed on the network with only *one* statement change! Level 3 has the most elegantly simple programming syntax ever offered on a computer network.

File syntax is as follows:

DEV A,B,C,D,	Local Floppies	unchanged from single user and timeshare systems
DEV E	Local hard disks	
DEV K-Z	Specific network Data Bases	

Each of up to 8 open files per user can be from 8 separate origins. Specific file and shared peripheral contentions are handled by 256 network semaphores
with the syntax Waite N
Waite N, close.

The network automatically prioritizes multiple resource requests and each user can specify a time out on resource requests. Semaphores are automatically reset on errors and program completion providing the system with a high degree of automatic recovery.



A Typical System

A typical system with two network data bases will have 148 megabytes of disk, four intelligent subsystems equipped with dual floppies, two dumb terminals, a word processing printer, a fast line printer, network data base manager software and 1000 ft. of inter-connecting cable. Utlizing .7 MIPS processors throughout it will cost less than $50,000 plus installation. GT option computers (1.2 MIPS) can be utilized at a slightly higher cost.

One Step at a Time

Best of all, Ohio Scientific users can develop distributed processing systems economically one step at a time. A user can start with a single user floppy system, add a hard disk, then time-sharing, then a second Winchester data base for backup and finally cluster intelligent terminals to achieve a full network configuration.

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The Microcomputers you should take seriously.

The Challenger III Series is the microcomputer family with the hardware features, high level software and application programs that serious users in business and industry demand from a computer system, no matter what its size.

Since its introduction in August, 1977, the Challenger III has become one of the most successful microcomputer systems in small business, educational and industrial development applications. Tens of thousands of Challenger III's have been delivered and today hundreds of demonstrator units are set up at systems dealers around the country.

The Challenger III systems offer features which make their performance comparable with today's most powerful mini-based systems. Some of these features are:

Three processors today, more tomorrow.

The Challenger III Series is the only computer system with the three most popular processors— the 6502A, 68B00 and Z-80. This allows you to take maximum advantage of the Ohio Scientific software library and programs offered by independent suppliers and publishers. And all Challenger III's have provisions for the next generation of 16 bit micros via their 16 bit data BUS, 20 address bits, and unused processor select codes. This means you'll be able to plug a CPU expander card with two or more 16 bit micros right in to your existing Challenger III computer.

Systems Software for three processors.

Five DOS options including development, end user, and virtual data file single user systems, real time, time share, and networkable multi-user systems.

The three most popular computer languages including three types of BASIC plus FORTRAN and COBOL with more languages available from independent suppliers. And, of course, complete assembler, editor, debugger and run time packages for each of the system's microprocessors.

Applications Software for Small Business Users.

Ready made factory supported small business software including Accounts Receivable, Payables, Cash Receipts, Disbursements, General Ledger, Balance Sheet, P & L Statements, Payroll, Personnel Files, Inventory and Order Entry as stand alone packages or integrated systems. A complete word processor system with full editing and output formatting including justification, proportional spacing and hyphenation.

OS-DMS, the software star.

Ohio Scientific offers an Information Management system which provides end user intelligence far beyond what you would expect from even the most powerful mini-systems. Basically, it allows end users to store any collection of information under a Data Base Manager and then instantly obtain information, lists, reports, statistical analysis and even answers to conventional "English" questions pertinent to information in the Data Base. OS-DMS allows many applications to be computerized without any programming!

The "GT" option yields sub-microsecond microcomputing.

Ohio Scientific offers the 6502C microprocessor with 150 nanosecond main memory as the GT option on all Challenger III Series products. The system performs an average of 1.5 million instructions per second executing typical end user applications software (and that's a mix of 8, 16 and 24 bit instructions!).

Mini-system Expansion Ability.

Challenger III systems offer the greatest expansion capability in the microcomputer industry, including a full line of over 40 expansion accessories.

Networking and Distributed Processing

OS-65U level 3 now provides networking capabilities as well as time sharing ability allowing Challenger III based systems to be expanded to meet the most demanding business applications.

Prices you have to take seriously.

The Challenger III systems have phenomenal performance-to-cost ratios. The C3-S1 with 48K static RAM, dual 8" floppies, RS-232 port, BASIC and DOS has a suggested retail price of under \$4000. 80 megabyte disk based systems start at under \$13,000. Our OS-CP/M software package with BASIC, FORTRAN and COBOL is only \$600, and other options are comparably priced.

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Letters

Tic Tac Rebuttal

In his letter to BYTE (October 1979, page 175), Mr Miller raises some interesting points. However, his comments about my Tic-Tac-Toe program (BYTE May 1979, page 196) do require further examination.

Apparently, aesthetics in programming is in the eye of the beholder; Mr Miller found my table-lookup method unappealing. It is more aesthetically pleasing to me to compute a move only once, then use it, rather than to recompute the same move each time it is used. Since a Tic-Tac-Toe game is readily represented as a decision tree, I felt that a table-lookup algorithm was the most natural implementation, and regretted the necessity of using more clumsy methods for the special cases.

A further advantage of a table-lookup method is its modularity; one move-logic block may be readily changed without affecting other parts. You may recall that there was a logic bug in the published program (see "BYTE's Bugs," August 1979, page 194). This was easily corrected by changing only five numbers in the data table.

The concept is similar to that of a chess program; the better ones use a table-lookup for the early moves of the game, before things get too complicated.

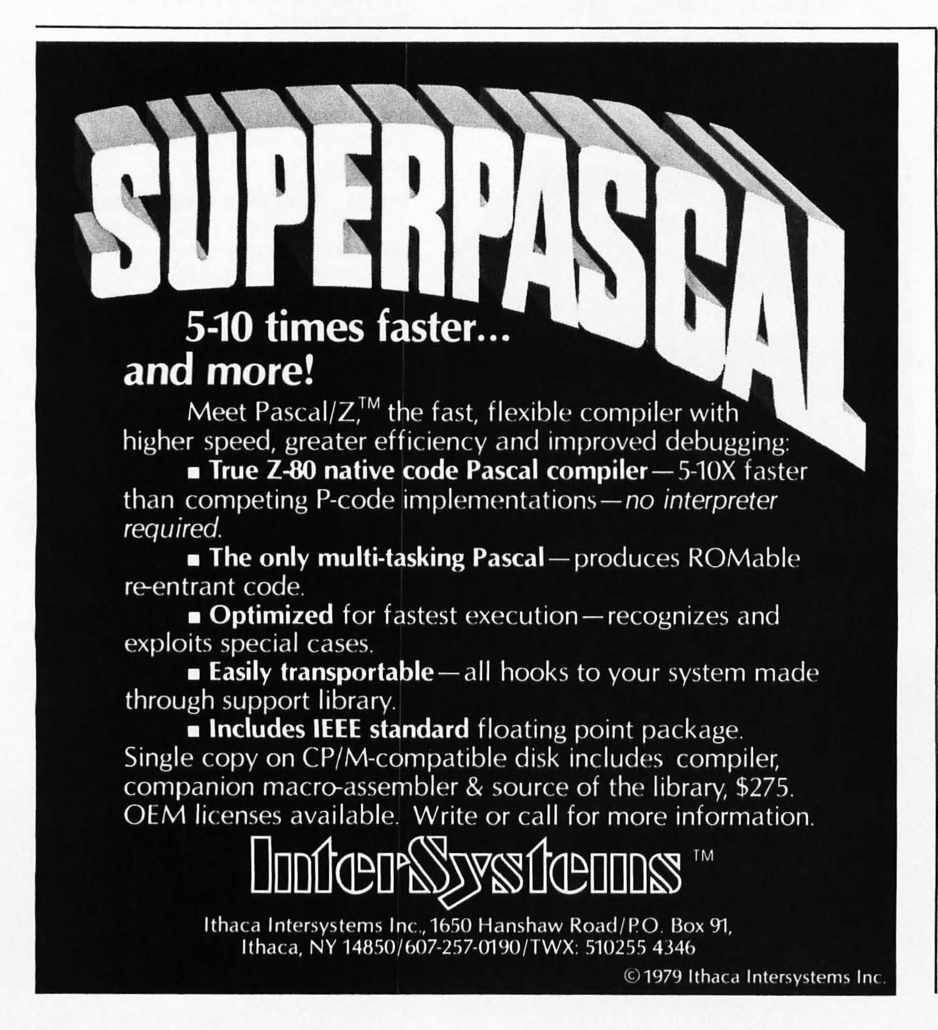
As for taking advantage of the microprocessor's capabilities, it is more natural for it to increment an address to find a prestored number than to compute; its built-in computing power is limited to addition. More complicated computing must be done by "brute force and awkwardness" in the machine-language programming of the BASIC interpreter.

Mr Miller did not like for the computer to always move first. As I stated in the article, I wanted the computer to play an aggressive game. It is readily apparent that the computer *cannot* play an aggressive game if the user moves first; it can then play only a defensive game, and wait for the user to blunder. Actually, I do have a user-first Tic-Tac-Toe program that uses a similar table-lookup method of play. While it plays the best possible game within the limits of a user-first game, it is still "curiously limited" and I felt that its inclusion would detract from the performance of the published program.

To play a rational Tic-Tac-Toe game, it is necessary but not sufficient for the program to be unbeatable. A rational program must not just respond to the current situation, but it must be goal-oriented. To set a "trap" requires three moves in the proper sequence. This planning ahead is readily done with a table-lookup method, but I suspect that it would be difficult to do by following Mr Miller's proposed system.

I suggest that Mr Miller submit a Tic-Tac-Toe program based upon his 9-step strategy. It is much more meaningful to compare the performance of working programs than to compare a working program with a theoretical one.

Delmer D Hinrichs
2116 S E 377th Ave
Washougal WA 98671



UNIX-type File Available

We applaud Jim Howell's plea ("Operating Systems: Let's Have Some UNIX-Inspired Software," September 1979 BYTE, page 82) for more sophisticated system software on microcomputers.

We would like to point out that UNIX-style file systems are, however, available already for microprocessors (at least the 6800s) in our SDOS product.

The SDOS file system supports files which may be randomly addressed to the byte; as many bytes as desired may be read or written in a single system call. Sector sizes of the disk hardware underlying the file system are completely invisible to the application program. Disks with different capacities and sector sizes can even be mixed on the same system. Regular I/O devices such as terminals and printers are treated identically, with the result being that applications object programs move unchanged from one SDOS hardware configuration to another.

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Also, like UNIX, SDOS is completely interrupt-driven.

SDOS currently runs on seven manufacturers' systems, handling over ten different types of drives, including floppy, Winchester, and 10 M byte cartridge drives.

We point out the obvious disadvantages of systems such as FLEX and CP/M; they are tied (and thus tie the application) irrevocably to the floppy disk hardware to which they were originally attached. Further, file I/O under these systems requires a lot of knowledge (ie: code) in the application to perform random access.

Yes, the industry does generally need more sophisticated system software.

Ira D Baxter
Software Dynamics
2111 W Crescent, Suite G
Anaheim CA 92801

A Stitch in Time?

Karen Wolfe's article in October BYTE "Power Helps Analyze Electric Bills," (page 48) led me to analyze Karen's sewing power. With the assistance of a sewing machine and a pocket calculator, neither of them programmable, I reached the following conclusions: For 100 hours running time on the sewing machine she probably spends close to eight hours a day sewing, including cutting, pinning, etc.

In a month Karen sews about 21 miles — that's 25,000 double seams the full length of the kid's jeans. 50 miles of thread speed through denim. Enough to weave 400 square feet of new cloth.

If Karen is ahead of the game and is in fact getting her stitches in in time, she is saving 189 miles of sewing each month. If she is not in time, she is wasting 18.9 miles of stitches, 45 miles of thread, and $1.38 of electricity.

Ken Bramham
apt 160, 15 rue Leon Bloy
92260 Fontenay-aux-Roses
FRANCE

Willard Irwin Nico 1928 - 1979

Personal computing pioneer and author Bill Nico passed away recently in Houston, Texas. Bill died of cancer July 2, 1979 at the age of 50.

Bill Nico is perhaps most widely known for his writing. He wrote several articles for BYTE ("Shooting Stars," May 1976; "Sys 8½," January 1977; "Sweet Auto Line," February 1977) and was author of Heath Company's best selling, self-instructional courses *BASIC Programming* and *Assembly Language Programming*. One of Bill's personal friends was Robert Tinney, artist for many BYTE covers. Robert drew Bill on the December 1977 cover.

Not so well known is the fact that Bill Nico was one of the first real computer hobbyists in the US. Bill's homebrew 8080 computer built in 1974 had to be one of the first in the country.

Bill was also one of the best BASIC and 8080 programmers around. He could get more out of his disk-based IMSAI than anyone. He could write systems software and languages, but felt just at home with a small business package or a real-time industrial control program.

Bill was also pretty good at hardware. He was a professional logic designer and did a fair amount of consulting in this field. His home was perhaps one of the most fully automated in existence. It was a virtual electronic showplace. Bill was also an active amateur radio operator (W5PRZ).

It was only in recent years that Bill discovered his talent for teaching. Bill taught frequently in Heath's computer classes. His great empathy and personal awareness made him a gem of a teacher. His practical nature and down-to-earth approach made him the favorite of every student. It was hard not to learn in his classes.

Bill Nico was born August 30, 1928 in Los Angeles. He graduated from Burbank High in 1946 and served in the Army from 1950 to 1953. His electronics training came from Pierce College in Los Angeles. Bill worked in a variety of electronic engineering and sales jobs in California and Texas from 1953 to 1969. He was manager of the Heathkit Electronic Center in Houston from its opening in 1969 until 1975 when he left to form his own company. From 1975 to 1979 he operated as a consultant and writer from his Houston-based firm, Delta-t.

Those of us who knew and worked with Bill will miss him greatly.

Lou Frenzel
1588 Oak Ter
St Joseph MI 49085

Marsport Forces Resurface

Mr Reiland made some comments about my "Marsport" article (April 1979, page 84) in his letter to BYTE (October 1979, page 209). While I appreciate his compliments, I do differ with him on

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one point: he objected to my statement about a circular orbit, "The attraction of gravity is exactly balanced by the centrifugal force at all times." All that I can say is, if this is "confusion," I am in good company. In the NASA book *Space Mathematics* (January 1972, page 119), two forces are defined:

$F_1 = mv^2/r$

where:

F_1 = Centripetal force
m = Mass
v = Velocity
r = Radius from center

$F_2 = GMm/r^2$

where:

F_2 = Gravitational force
G = Universal gravitational constant
M & m = Masses of the two bodies
r = Radius between centers

They then say, "The physical situation, *if these two forces are equal*, is represented in . . . (a circular orbit)." (Emphasis added.) They further show how, by setting these two forces equal, one can solve algebraically for the circular orbit velocity. While their terminology is slightly different from mine, their meaning is obviously the same as I expressed.

One further point: Mr Reiland seemed surprised that a three-dimensional landing simulation could be programmed on a programmable calculator. This program is far from the limit! I have since programmed a similar three-dimensional *rendezvous* simulation, that keeps track of *two* objects in their orbits simultaneously. In it, the spaceship is initially at rest on the surface of the primary, while a target satellite is in a random elliptical orbit. The user waits until the satellite is in the best position, lifts off, matches orbits with the satellite, and rendezvous with it. To try this more difficult exercise, send $1 to cover my copying and postage costs for a 12-page write-up and listing for the HP-67/97 (as submitted to the Hewlett-Packard Users' Library). Include two blank magnetic cards and I can record the program on them.

Delmer D Hinrichs
2116 S E 377th Ave
Washougal WA 98671

It Happened Again

It has happened again. Every time I decide to let my BYTE subscription lapse because of the high price of the magazine, along comes an issue so jam-packed with well-written, informative, readable articles, that I am *forced* to renew my subscription again. The most recent issue, the one on LISP (August 1979), just did it again.

The LISP articles simply covered almost everything one would want to know in an introduction, and did it well. In addition, there were excellent articles on more advanced subjects — symbolic math systems and pattern-directed languages being the prime cases to point to — for those who want to delve deeper, or who already knew LISP and its implications and implementations. All of these articles were well-written, too!

Amazing is the only word.

Dave Mellinger, LISP hacker
c/o Datek Inc
2336 Wilson Blvd
Arlington VA 22201

Elegant Input Recognizer

While working on a Star Trek program, I came across the problem of command mnemonics. I wanted the user to be able to type commands as alphabetic mnemonics, not numbers (for example, TRP for torpedo). Also, I wanted him or her to be able to type in the initial of the mnemonic, also for expediency.

However, I did not want the remaining letters to be arbitrary (having the computer recognize only the first letter would mean that THE PHASERS would work for TRP). It's not easy to memorize the mnemonics, so users could easily make mistakes in typing in commands, thereby moving two quadrants west when they wanted to fire the photon torpedo banks. I have seen this happen on many occasions. So, I did a little brainstorming, and came up with this:

```
IF LEFT$("TRP",LEN(A$)) = A$
THEN PRINT "TRP"
```

This works just as well for YES. This one-line comparison will allow "Y," "YE," or "YES," but not "YEAH," "ALYESKA," or even "YESNO." I agree that it is really not necessary to put all that user-input protection in a computer-assisted instruction (CAI) program, but if you want to use it, you can implement it very easily in any BASIC with LEFT$ and LEN. It's also useful for other applications, such as my Star Trek problem.

Mits Hadeishi
1460 W 182nd St
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Making Color Slides with an Intecolor Microcomputer

Alan W Grogono
State University of New York
Upstate Medical Center
750 E Adams St
Syracuse NY 13210

Slides are required for many demonstrations and lectures. Instuctional slides often consist of a few words or a simple diagram or graph which the lecturer wishes to discuss. In recent years such slides have commonly been prepared as a blue diazo (white writing on a blue ground). Even the simplest slide is subject to about twelve processes: rough drafting, typing, checking, type setting, rechecking, photography, developing negatives, brushing out imperfections, diazo exposure, pickling, cutting, and mounting. Misunderstandings and interpretations mean that it is not uncommon for one or more stages to be repeated; the process is moderately expensive, and a diazo slide tends to fade with time. This article describes a quick, convenient method of preparing color slides using a computer.

Equipment

The computer employed is an Intecolor eight-color intelligent terminal equipped with BASIC and dual floppy disk. The choice of camera and film may depend on individual circumstances, but the author suggests the following: a single-lens reflex (SLR) 35 mm camera, mounted on a tripod, with telephoto lens (to reduce barrel distortion). Close-up lenses or close focusing attachments are essential.

1a

1b

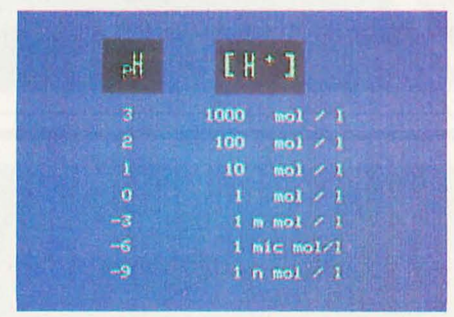


Photo 1: *Two examples of computer-generated slides containing color text material.*

The computer allows images to be formed on a high-resolution screen offering eighty characters per line and either forty-eight lines of small letters or twenty-four lines of double-height letters. Lines, bar graphs, vector graphics, and simple drawings can also be constructed. The color for the background and for the foreground (the character or line) can be separately selected from the eight available colors.

Software

A program called Menu is used to:

- prepare a new floppy disk for saving images,
- prepare images,

About the Author

Dr Grogono is an Associate Professor of Anesthesiology at the State University of New York, Upstate Medical Center, in Syracuse New York. He trained in London, England, and emigrated to the United States in 1974. He uses microcomputers with graphics for teaching, for recreation, and as described in the accompanying article, for color slide making. He has written many scientific papers in his specialty, anesthesiology, and is author and/or editor of several books. He is an active member of the American Heart Association and directs the Advanced Cardiac Life-Support Instructor's Course in Syracuse NY. For the New York State Society of Anesthesiologists annual meeting in New York, he runs the panel "Research by New Investigators." He is also a member of the Icarus high-speed hydrofoil sailing project which set a B-Class, World Sailing speed record in Weymouth, England, in 1976.

- transfer the contents of the display memory onto the floppy disk

The program also places the computer into a suitable mode. The scroll mode is replaced by the page mode, and the screen image is made to correspond with the appropriate memory locations.

Image Preparation

Simple word slides are best prepared in *CRT mode* (a mode which allows direct user interaction with the graphics display). The keyboard allows letters to be positioned anywhere on the screen. Colored text, borders, and backgrounds are used for effect. Considerable rearrangement and adjustment is possible using the delete and insert keys for characters and lines. When the image is complete, the disk is inserted and the AUTO key is pressed to run the storage program. The image is automatically transferred to the disk to be photographed later. Examples of text slides prepared in this way are shown in photos 1a and 1b.

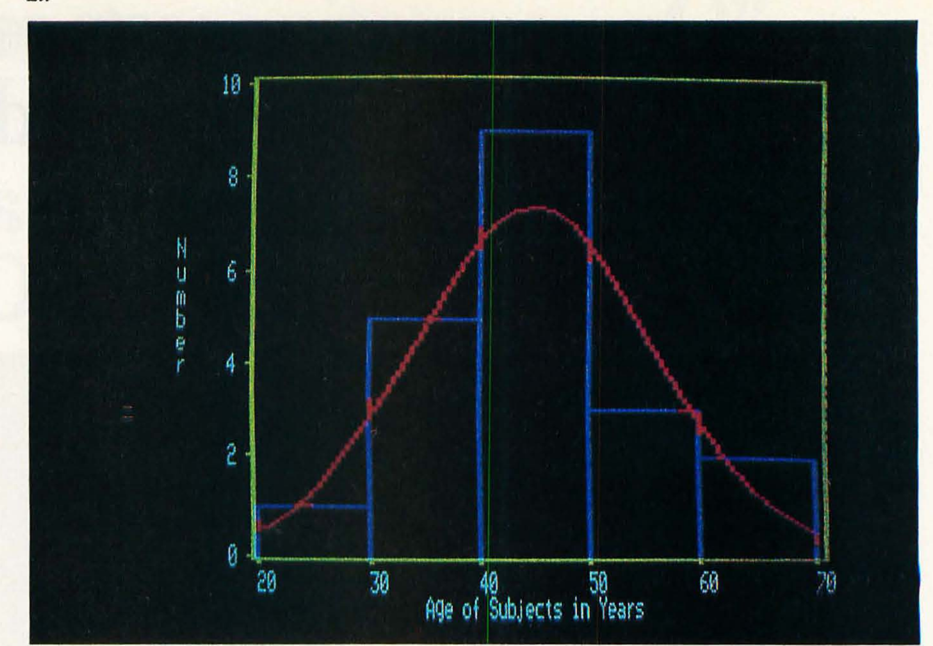
More complicated slides may be produced by employing a program to prepare the display (eg: to generate a graph or a histogram). Examples of slides prepared in this way are shown in photos 2a and 2b. When such a program is being written, it is important to remember that the process of transferring the image to disk uses a BASIC program that will replace the preparation program in memory.

Color Selection

Color slides are usually most successful when the image or letters are brighter than the background. With the bright foreground image, any spreading due to light-scatter on the cathode-ray tube, the film or the projection screen tends to enlarge a line or a character instead of extinguishing it. Therefore, of the sixty-four color combinations available, only about twenty are useful for slides.

If the alignment of the red, blue, and green electron beams in the cathode-ray tube is imperfect, the focus of the screen image may suffer. This problem may be minimized by judicious choice of foreground color. In such cases, use a color scheme in which the image is formed by turning only a single beam on and off as it sweeps across the tube. For example, with white text on a magenta background, only the green electron beam is modulated, and a good image can be obtained even if the beam alignment is poor.

2a



2b

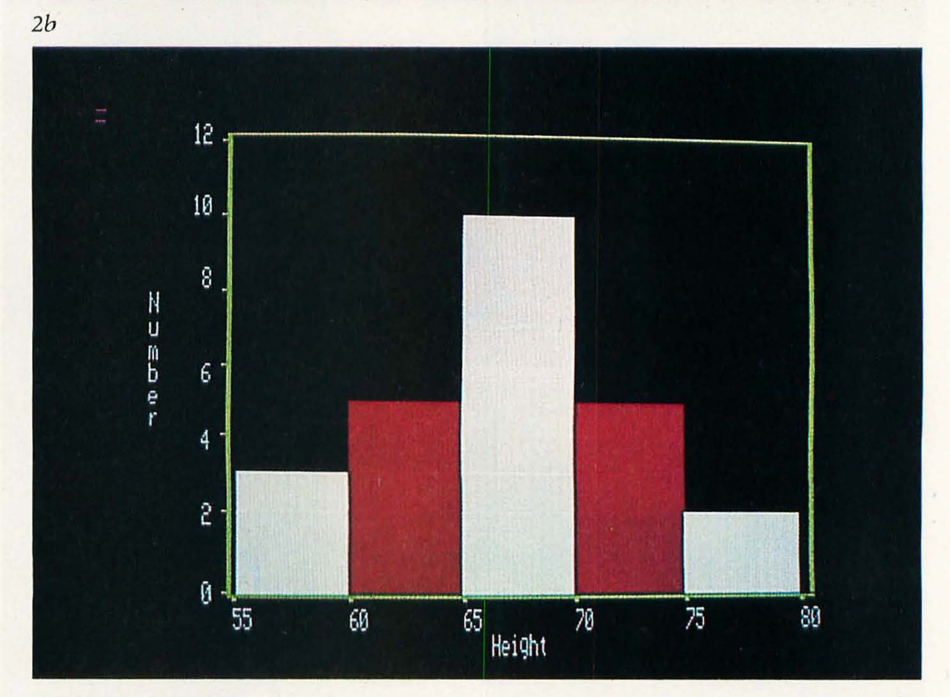


Photo 2: *Two examples of computer-generated slides containing colored graphic material.*

Photography

The images are recalled for photography using the same program. The program recalls the images one by one. Photographs must be made in ambient darkness to avoid unwanted reflections. Certain colors tend to require more exposure than others (eg: red and blue on black backgrounds).

Color film does not always reproduce television images perfectly. Red, in particular, may appear somewhat brown. A Kodak CC40R filter is supposed to correct this, but the exposure time required is doubled. I have prepared slides with and without the filter. I currently use Kodak Ektachrome 64 (ER-135) with no filter. The films, filters, and exposures I used are shown in table 1.

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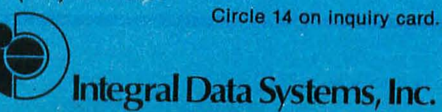
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Film	Speed (ASA)	Filter	Aperture f 3.5 Exposure Seconds
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Kodak Ektachrome ER 135	64	CC40R	1
Kodak Kodachrome KM 135	25	None	1
Kodak Kodachrome KM 135	25	CC40R	2

Table 1: *Exposures and films used to photograph displays on the Intecolor microcomputer.*

films to the manufacturer for developing and mounting: if slides have a black background, an automatic film cutter may be unable to recognize the frame boundaries. Several films have been returned irreparably damaged, sometimes with half of a slide in one mount and the other half in the next mount. The use of colored backgrounds is recommended for visual pleasure as well as preservation of your work. If you are in doubt, it is probably wise to ask for your film to be returned uncut.

Discussion

Slide preparation using a small computer and color-transparency film has a number of advantages; several colors can be used on a single slide, the photography is simplified, and the color slides are more durable. In addition, when the computer is suitably located, the drafting and checking are more convenient and may even be reduced to a single step. I now find it easy to design a slide at the keyboard. Decisions about spacing, positioning, and color can be made, revised, and implemented as the image is being prepared. This has reduced the first five steps to two, namely drafting the image and saving it on disk. The photographic process is reduced to making the exposures, developing the film, and mounting the slides — a considerable saving in steps and labor.

The quality of slides produced in this way is very pleasing. Audience members inquire how the slides are made and express appreciation of the color and the technique. Distortion is negligible, and the quality of curved and oblique graph lines is adequate for lecture slides (for the graphs the resolution is 1 in 160 on the X axis and 1 in 192 on the Y axis).

The cost of making slides is hard to evaluate. The lecturer's time and the time spent fetching, carrying, and checking are often assumed by the organization. However, even those costs that remain are significant. Between $6 and $10 is probably the minimum cost of laying out the simplest text and preparing a diazo slide. Slides for a one-hour lecture may cost approximately $500.

Preparing slides on the computer simplifies the photographic process. This alone represents a saving of about $2 per slide. The time spent designing the slide and arranging the layout can be reduced as well. However, any time spent employing the additional choices of colors and layouts may offset this potential savings to some extent. The disks used for storing the images cost $5, or about 50 cents per slide. However, the disks are reusable and should therefore not represent an appreciable cost per presentation.

The greatest savings would be realized by those illustration departments that are frequently expected to prepare histograms, regression graphs, scatter diagrams and graphs of functions. A few appropriate programs would allow numerical data or mathematical functions to be directly converted to color images. A final advantage is that Ektachrome processing is commonly available commercially on a same-day basis. Slides can be prepared, photographed and reviewed in twenty-four hours.

The computing equipment described in this article costs about $6000. Any illustration department handling much slide preparation, particularly that involving slides of graphs, should find it worthwhile to review the type of material they handle and its cost. The Intecolor computer has now been used to prepare hundreds of slides. A similar program will also work on the Compucolor II with only slight sacrifice in definition, resolution, and color rendition.■

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Computerize a Home

Steve Ciarcia
POB 582
Glastonbury CT 06033

I anxiously glanced around the Circuit Cellar. Devoid of the usual sounds of the stereo or television, the equipment fans imparted a distinctly uneasy sensation of mechanical presence.

The room was totally dark except for a few pilot lights and a video display. There were no games, no fast-moving program listings; only a single line was written on the screen. In the dim luminescence I could barely distinguish the furniture from the bookcases. A little experience navigating in the dark would have been useful, but I opted for modern technology and reassuringly patted the flashlight in my pocket.

I pushed the button on my digital watch and noted the time. As it neared the prearranged hour, I turned instinctively to the terminal. Soon I'd know which of us was in control!

Almost immediately the display changed and printed out "AUTOMATIC CONTROL INITIATED." Simultaneously I could hear a high-pitched noise. It sounded almost like an insect chirp. There are no crickets down here; it must be a subharmonic. So far so good, but did it work?

"Steve, did you just blow a fuse?" My wife stood in the doorway and called down the stairs. It didn't bother *her* that there weren't any lights on. After all, if you blow a fuse, shouldn't the lights be off?

"The kitchen light went off and the bedroom light came on. Wait! The bedroom light just went off and the kitchen light came back on. Now they're both off."

I grinned in a way that only a Cheshire cat could appreciate. "Sorry, Joyce, just experimenting on the latest article." Chuckling softly, I continued. "I hope you don't mind, but the computer seems to have taken over."

"Can it make beds?" she replied.

I should have known that she wouldn't be taken in that easily. "OK, I'll tell the computer to keep its sphere of influence to the cellar. I'll let you know what the password is later."

As if by magic, the Circuit Cellar lights were activated. The test was successful.

Security Versus Control

Even though it may seem true at times, our house has not been taken over by a computer. I was simply testing the latest addition to my home control system.

In previous issues of BYTE, I presented a series of articles on the construction of a home security system. (See "Build a Computer Controlled Security System for your Home": Part 1, January 1979 BYTE, page 56; Part 2, February 1979 BYTE, page 162; Part 3, March 1979 BYTE, page 150.) This was not a theoretical dissertation. It was, in fact, an overview of the system installed in my house. The original concept was configured around a single-board 8085 system and designed primarily as an alarm controller. Even though it works, it has definite limitations.

Eventually I became dissatisfied with just having a super burglar alarm. It seemed a shame to dedicate all that hardware and expense to a function with such a limited capacity. The obvious step was to expand the concept to be a "home control" system where security is but one of many possible applications. To do this requires more memory; the single board has been replaced by a 26 K byte Z80-based computer with a video display. Operating in either high-level or assembly language, it is as adept at keeping the checking account straight as it is at scanning input ports searching for an intruder. Add to it the ability to activate and communicate with my large disk-based development system, and it is indeed a powerful tool.

The major difference between the two system concepts is the output control structure. As an alarm, the computer is strictly configured to scan and analyze a multitude of event inputs, such as door switches and motion sensors. Its decision process is immediate, but its output control is relatively limited. These generally consist of several lights, a siren, and an automatic phone dialer. Even in

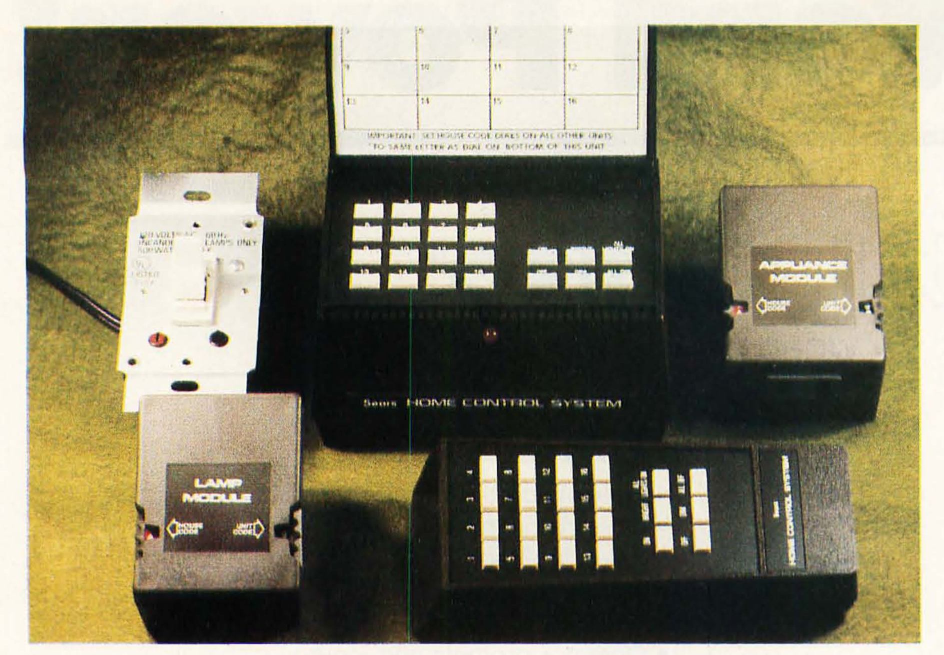


Photo 1: *BSR X-10 system as marketed by Sears and called the Sears Home Control System.*

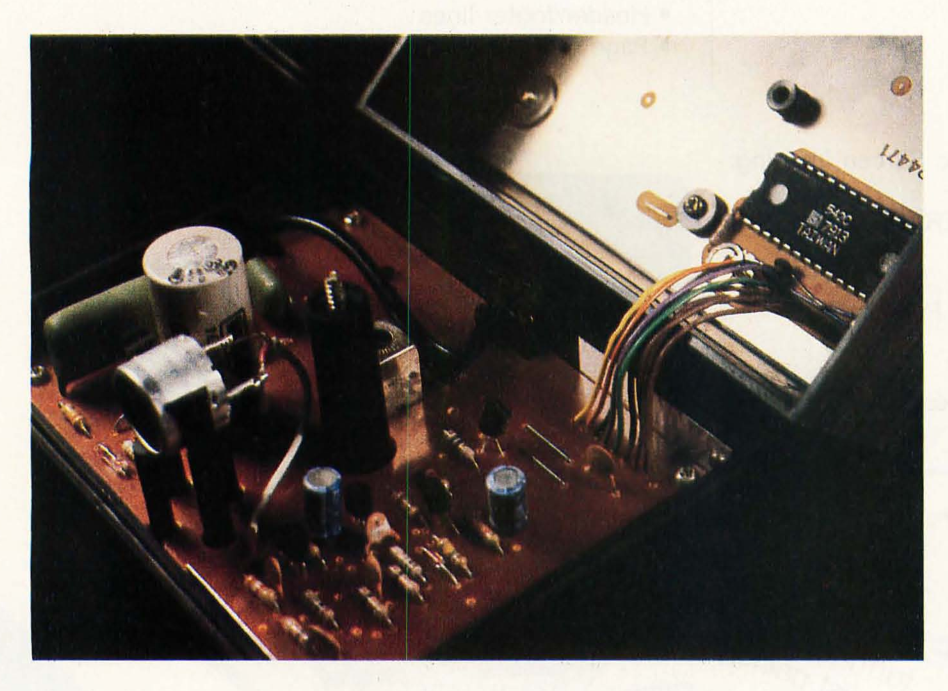


Photo 2: *The internal electronics of the command-control console.*

the sophisticated system I presented, these hardwired outputs were kept to a minimum to reduce costs.

Generalized home control extends computer control capability far beyond the few outputs of the original system. It is conceivable that all of the lights and AC outlets in the house could be affected. A few lights outside are barely enough. Lighting in the bedrooms, kitchen, and garage should be included, with the stereo and television thrown in for good measure. If you live in a cold climate and use an automobile engine-block heater, why not turn it on automatically before you get up in the morning? Tired of searching around in the dark for the light switch? Let the door sensor from the alarm system trigger the lights as you walk into a room. How about some soft music ten minutes after you enter? The list is endless.

This expansion seems to be a contradiction considering my previous concern over wiring costs. To accomplish this feat, either every AC outlet must be directly wired to the computer through relays as in the original system *or* the control capability must be added remotely to each light and appliance.

AC Remote Control

This latter suggestion is not as farfetched as it might seem. There have been many technological advances in the past year. One of the more significant achievements comes from BSR (USA) Ltd—specifically in the area of AC remote control. The BSR X-10 control system is shown in photo 1. Clockwise from the center, the five components are: command console, appliance module, cordless controller, lamp module, and wall-switch module. With these units, low-cost AC control is a reality.

The BSR X-10, also marketed by Sears as the Sears Home Control System, operates through carrier current transmission from the command console to the receivers. When a button is pushed on the command console to activate a remote receiver, a coded signal is sent through the house wiring. Each receiver monitors these transmissions and responds only when its particular code is sent.

Figure 1a is a block diagram of the $39 command module and photo 2 shows its internal electronics. The heart of this, as well as the other system components, consists of custom large-scale integration (LSI) chips manufactured for BSR by General Instrument Corp. In normal operation the twenty-two-button keypad is continuously scanned. When a key is pressed, this designated function and a house code (previously set by a thumbwheel switch on the bottom of the command console) are combined into a single message. The digital message is directed to the transmitter section, where it modulates a 120 kHz carrier. The control signal appears on an oscilloscope as a series of pulse bursts. This is shown in photo 3.

There is a second method where the command console designates a control function and transmits a message. Each control console contains a ultrasonic receiver. In the picture this is the metallic cylindrical component with the two protruding pins and shielded cable soldered on them. The BSR X-10 system facilitates

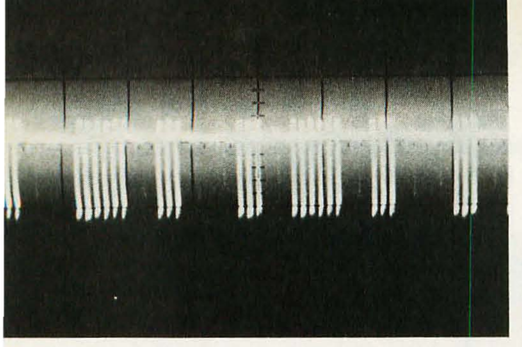


Photo 3: *Oscilloscope picture of command-control console transmission on the AC line. (Photo courtesy of Mark Scheffler.)*



Photo 4: *Handheld cordless controller showing top and internal circuitry.*

1a

40 kHz TRANSDUCER
40 kHz ULTRASONIC RECEIVER
22 BUTTON KEYPAD (SCANNED)
CUSTOM LSI IC (24 PIN)
120 kHz CARRIER CURRENT TRANSMITTER
HOUSE CODE SWITCH
110 VAC 60Hz
20V POWER SUPPLY (TO ALL SECTIONS)

1b

15A 115VAC SOLENOID ACTIVATED SWITCH
115VAC OUTPUT TO APPLIANCE OR LIGHT
120 kHz CARRIER CURRENT RECEIVER
CUSTOM LSI IC (18 PIN)
HOUSE AND DEVICE CODE SWITCHES
110VAC 60 Hz
DC POWER SUPPLY (TO ALL SECTIONS)

1c

40 kHz TRANSDUCER
40 kHz ULTRASONIC TRANSMITTER
CUSTOM LSI IC (24 PIN)
22 BUTTON KEYPAD (SCANNED)
9 V BATTERY

Figure 1: *Block diagrams of the integral parts of the BSR X-10. The block diagram for the control console is given in figure 1a, the appliance module in figure 1b, and the remote control transmitter in figure 1c.*

remote channel and function selection through a handheld ultrasonic transmitter. This unit is shown in photo 4 and diagrammed in figure 1c.

When a key is pressed, it is encoded and transmitted as a series of 40 kHz tone bursts. The command console, receiving this information through its ultrasonic receiver section, takes this data as if a button had been pushed on the command console. It then adds the house code and simultaneously transmits the command message over the house wiring.

The receiver part of the system is also quite sophisticated, considering that each receiver costs less than $15. These receivers, shown in photos 5 and 6, can be placed virtually anywhere. An overhead light can be accommodated by replacing the standard on/off wall switch with a wall-switch module. An appliance such as a dehumidifier is controlled through an appliance module.

All receivers are basically the same. A block diagram of an appliance module is shown in figure 1b. The receiver section monitors the AC line waiting for a coded message corresponding to its unique house (A thru P) and unit device (1 of 16) code. To turn on channel 10, simply press "10" and then the "ON" button sequentially. When the appliance module activates, it sounds like a relay engaging. In actuality, BSR uses an inexpensive solenoid to operate a 15 A push-button Microswitch.

The lamp and wall-switch modules use a triac instead of this pseudo-relay. Unlike the appliance module, which only operates as an on/off switch, these units have the additional ability to automatically brighten or dim when the corresponding function buttons are pressed on the command console. Finally, all receivers can be locally activated without the command console. To turn on a light or motor, simply flip the power switch from on to off and


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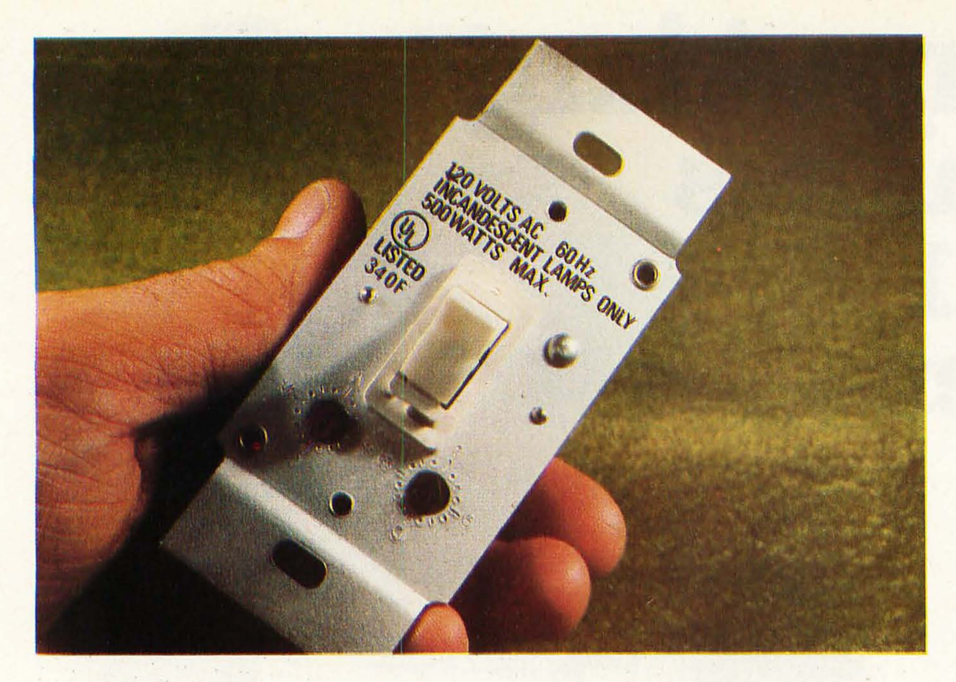


Photo 5: *The wall switch module replaces standard wall switch and allows remote control. Two slotted-top rotary switches under the switch lever are for setting house and device codes.*



Photo 6: *The appliance module.*

back to on again. This automatically triggers the receiver module into an on condition.

Controlling the BSR X-10

When I first started using the BSR X-10, I could hardly believe its versatility and low cost. The only problem is that operation of the BSR X-10 is completely manual. The only way to use the control receivers is through the command console or ultrasonic transmitter and by physically pressing the buttons.

I would not say that I have a never-say-die attitude, but considering my original security system, with an average cost of $250 per AC output channel, my future computer-controlled house depended heavily on less expensive input/output (I/O). It was absolutely necessary to find some method of utilizing the control receivers.

Three possible solutions came to mind:

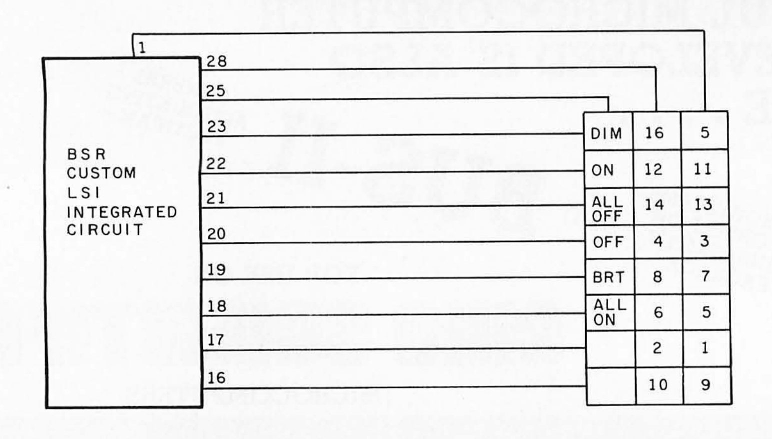
- Directly synthesize the command-console waveform and transmit it directly onto the AC line.
- Brute force contact closure—attach either relays or complementary-metal-oxide semiconductor (CMOS) switches in parallel with the push buttons and activate the relays from the computer.
- Synthesize the waveform from the ultrasonic controller and let the computer "talk" to the command console.

Simulating the command-console output sounds simple in theory. (This is somewhat like estimating software costs.) Simulating the device-control code and using it to modulate a 120 kHz carrier frequency leads to contact with a hostile environment. The output from the computer must be attached to the AC line. This requires isolation through either transformers or optoisolators, plus many discrete components to properly match impedances. It is a shame to reinvent the wheel when BSR has already designed such an effective transmission system. Although possible in theory, this approach is too messy to warrant further consideration.

The second alternative is brute force. This can usually work, but you must be careful. In essence this method entails wiring relays or CMOS switches across the push buttons and remotely, but still mechanically or electronically, closing the contacts corresponding to a particular button. Figure 2a illustrates the keypad connections for both the command console and cordless controller. The configuration is a 3 by 8 scanning matrix. To turn on channel 6, simply short pins 28 and 18 together. Likewise, "dim" would be pins 25 and 23. While twenty-two separate single-pole, single-throw switches could be used, figure 2b demonstrates an easier alternative.

Two CMOS switches can be used in combination with the ultrasonic controller to provide this capability. Connected to 5 bits of a latched parallel output port, the two integrated circuits channel the appropriate lines together. To turn on channel 12, a row-select code of binary 001 would be set on B2, B1,

2a



2b

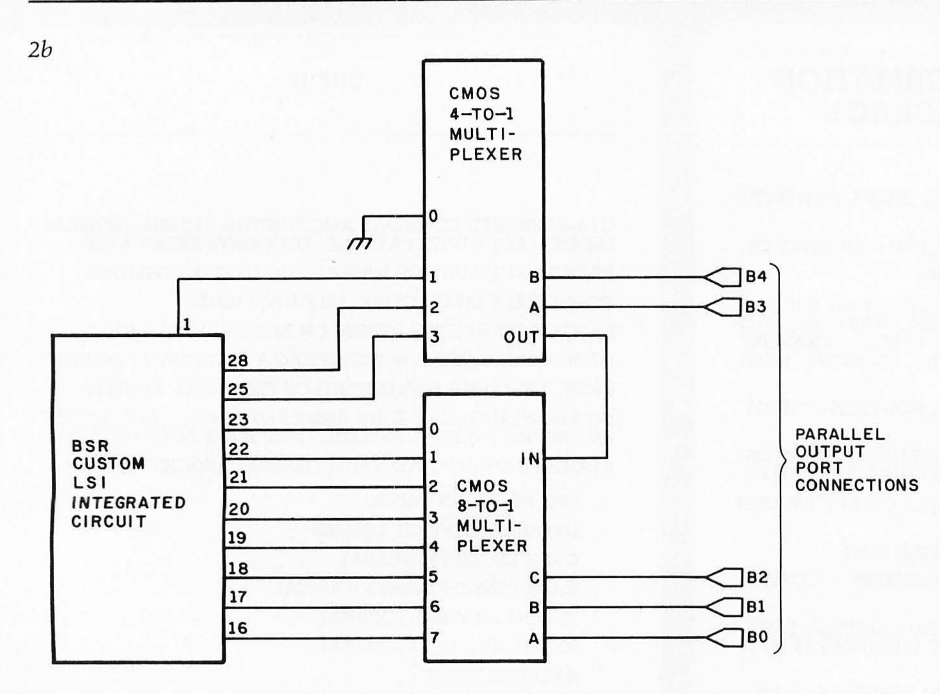


Figure 2: *The keyboard in the BSR X-10 command console and remote control unit is connected to a custom LSI integrated circuit. Figure 2a shows the keyboard in relation to lines coming from the BSR custom integrated circuit. The functional schematic in figure 2b could be used to replace the keyboard with an I/O port.*

and B0, respectively, and a column-select code of binary 10 would be set on B4 and B3. The ON key would be a code of 11100 for bits B4 thru B0, for example.

The circuit of figure 2b will work only with the handheld battery-controlled unit. The command-console electronics, which run on −20 V, can use the same logical concept, but relays must be substituted for the CMOS switches. The command console is not isolated and its electronics are floating at 120 VAC. To be totally safe, it is best not to bother with it.

Hardwiring to the handheld unit keyboard will work, but it also has some detrimental features. In operation, the ultrasonic unit consumes an average of 30 mA, while peak currents are about 100 mA. Alkaline batteries are a must. Short of direct connection to the computer's power supply through a 9 V regulator, there is always the hazard of battery brownout. If I were depending upon this system, I would not have a critical component powered by battery.

Talking to the BSR X-10

The sensible alternative is to construct an interface that facilitates cordless communication between the computer and the BSR X-10 command controller. Safety is the primary consideration. There is no hazard in using the controller or receivers as long as their cases are intact. The BSR X-10 is Underwriters' Laboratories listed. Attachments between the computer and the command module must be done carefully and only by experienced people. By maintaining the structural integrity of the components, you are not limited to use with the computer. The command console can be moved around the house, and it is placed within range of the computer only when automatic control is desired.

Practical accomplishment of this goal is achieved using the ultrasonic receiver found within the command module. An interface is constructed that formats function codes into message strings; these strings are transmitted to the command console as 40 kHz pulses. In essence, the interface simulates the activity of a cordless-controller unit.

Figure 3 describes in detail the communication between the two subsystem components. Each of the twenty-two buttons has a unique 5-bit code (listed in table 1). For example, channel 5 has a code of 00010 with respect to bit positions D8, D4, D2, D1, and F. The ALL LIGHTS ON key generates the code 00011.

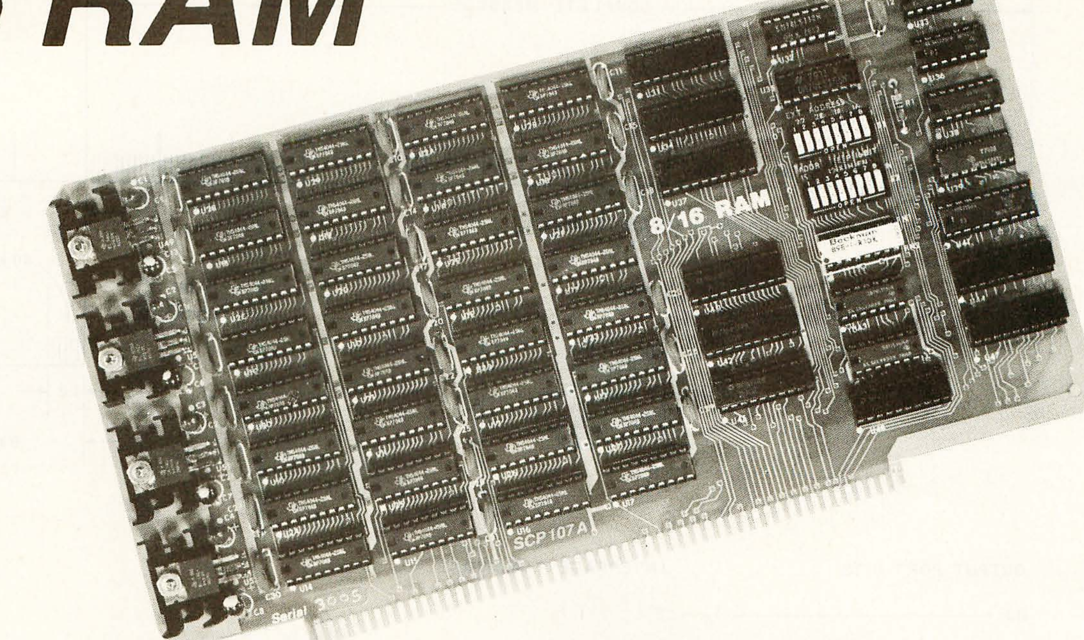
The actual message that communicates this selection is approximately 100 ms long and is composed of thirteen 8 ms segments. Each segment consists of a burst of 40 kHz directed to an ultrasonic transducer. Data is pulse-width modulated. A logic 1 is a 4 ms burst and a logic 0 is a 1.2 ms burst.

To signify channel 5, the interface first sends a start bit to alert the receiver of the pending message transmission. This is a 40 kHz tone for 4 ms. Next, the 5-bit selection code is sequentially transmitted as a series of 1.2 and 4 ms bursts of 40 kHz. This is followed by transmission of the logical inversion of the 5-bit selection code and a 16 ms end-of-message tone. All messages use the same format; only the 5-bit selection code varies.

Figure 4 is an interface specifically designed to send this message and facilitate wireless remote control. Incorporating complete circuitry for address decoding and data storage, it appears to the computer as a single output port. Turning on the table lamp is as simple as sending a 1-byte output to the interface port. As with

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8/16 Fully Meets IEEE Standard

The 8/16 was designed to be in full compliance with the proposed IEEE Standard for the S-100 Bus. This Standard defines extensions which allow 16 data bits and 24 address bits while maintaining compatibility with the original bus. The 8/16 fully implements these extensions, and thus can be expected to interface smoothly with these new 16-bit machines.

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The 8/16 chooses a data path width of 8 or 16 bits by sampling the newly-defined bus line over which the "Sixteen Request" signal is sent. All 16-bit processors will use this signal. If it is present, the 8/16 organizes itself as 8K by 16 bits. If it is absent, the 8/16 is 16K by 8 bits wide, just like any other 8-bit memory. Thus data path width selection is automatic.

For your 8-bit machine. . .

To use the 8/16 in your 8-bit machine, all you need to do is set the address of the board on its DIP switches and plug it into your computer. The 8/16 offers "extended addressing" as proposed by the IEEE, which is an alternative to "bank select" in opening adress space beyond 64K. With extended addressing, memory can appear as a smooth, continuous block of up to 16 megabytes, any of which can be accessed at any time. This contrasts with bank select in which blocks of up to 64K are switched on and off by special software. If your system does not provide the 8 extra address lines required for extended addressing, this feature may be disabled and the extra lines ignored at the flip of a switch. The 8/16 is fully static so there is no need for concern over clocks or in applications using DMA. Our current one-year reliability on similar boards is 98% so you can expect years of trouble-free service from your 8/16.

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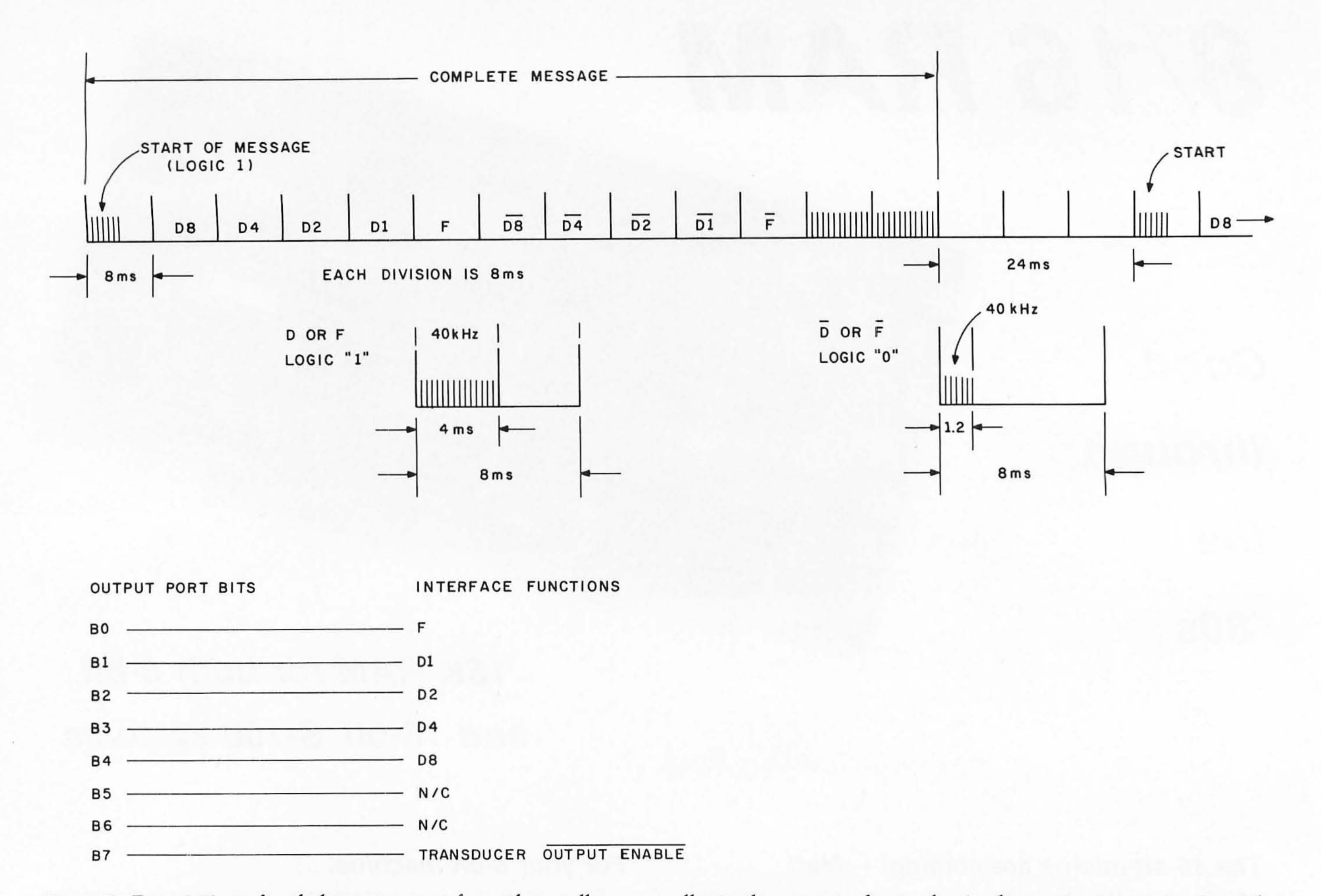


Figure 3: *Description of coded message sent from the cordless controller to the command console via ultrasonic communication. The necessary codes are shown in table 1.*

the majority of my designs, it is both processor and speed independent. It works equally well in BASIC or assembly language programs. Connected to port 9 (as in my example software), turning on a table lamp or the hall lights in BASIC is a one-line command, OUT 9,5 (from the code list of table 1). Turning it off is simply OUT 9,7.

The circuit will work on virtually any computer, although the pin designations in figure 4 refer specifically to the Radio Shack TRS-80 Model I. All connections are made directly to the computer address and data buses. In the TRS-80 this is done through the expansion connector. In a computer such as an Apple II, the circuit could be built to plug directly into the back-plane connector or to be connected by a ribbon cable.

The electronics can be divided into three subsystems: port latch and address decoding, pseudo pulse-width modulator, and message serializer. Photo 7 illustrates the prototype of figure 4.

ICs 9 thru 13 make up the address decoding and data latch. For a TRS-80, I have arbitrarily chosen an address of 127 decimal (in my software examples, I use port 9). When the address bus and $\overline{OUT}$ line (corresponding to $\overline{I/O\ WRITE}$ on some systems) indicate execution of an output command, the contents of the data bus are stored in ICs 11 and 12.

CHANNEL NUMBER OR FUNCTION	BINARY CODE D8	D4	D2	D1	F	DECIMAL OUTPUT TO INTERFACE CIRCUIT
1	0	1	1	0	0	12
2	1	1	1	0	0	28
3	0	0	1	0	0	4
4	1	0	1	0	0	20
5	0	0	0	1	0	2
6	1	0	0	1	0	18
7	0	1	0	1	0	10
8	1	1	0	1	0	26
9	0	1	1	1	0	14
10	1	1	1	1	0	30
11	0	0	1	1	0	6
12	1	0	1	1	0	22
13	0	0	0	0	0	0
14	1	0	0	0	0	16
15	0	1	0	0	0	8
16	1	1	0	0	0	24
ALL OFF	0	0	0	0	1	1
ALL LIGHTS ON	0	0	0	1	1	3
ON	0	0	1	0	1	5
OFF	0	0	1	1	1	7
DIM	0	1	0	0	1	9
BRIGHT	0	1	0	1	1	11

Table 1: *Cordless controller push-button codes and decimal equivalents.*

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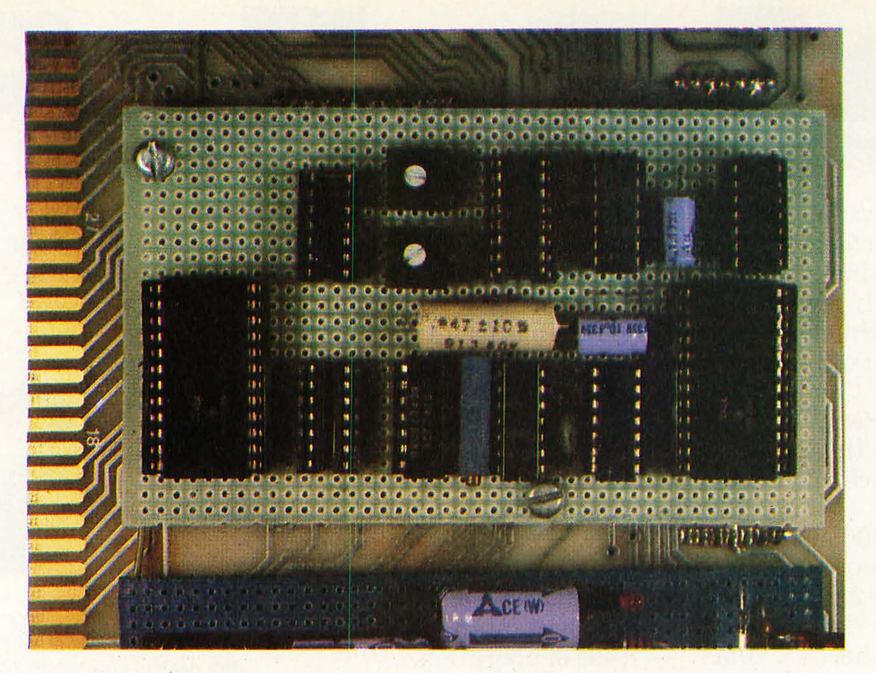


Photo 7: *Prototype of the circuit shown in figure 4. The ultrasonic transducer is remotely located, and ICs 9, 10, 11, 12, and 13 are contained on another board.*

Bits 0 thru 4 will contain the function code (from table 1) and bit 7 is used to turn the transmitter output on and off. For further information on address decoding and output ports, I refer you to *Ciarcia's Circuit Cellar* from BYTE Books and the article entitled "Memory Mapped I/O," which first appeared in the November 1977 BYTE, page 10.

In figure 4, the 5-bit function code, as well as its logical inversion, are attached to a 16-to-1 multiplexer, IC1. As the 4-bit counter IC7 increments, each of the input lines of the multiplexer is sequentially routed to the output, pin 10. With address position 0 permanently tied high and the next ten addresses wired as function-code inputs, the output of IC1 will reflect the first eleven 8 ms message segments.

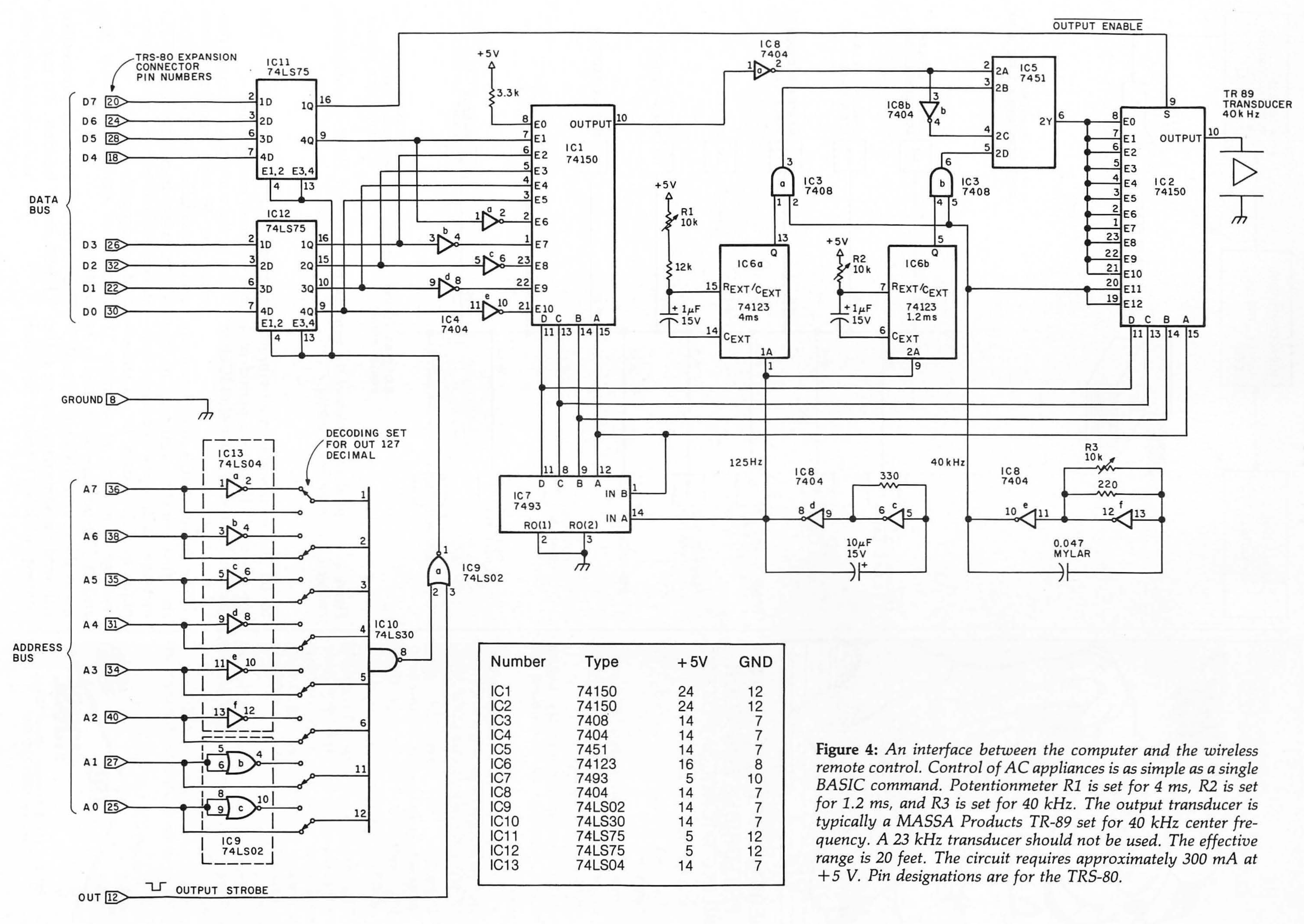
ICs 3, 5, 6, and 8 act as a digital modulator. If the output of IC1 pin 10 is a logic 1 (such as the start bit), a 4 ms burst of 40 kHz will be routed through IC5 and appear at pin 6. A logic 0 on pin 10 results in a 1.2 ms burst. The timing of these events is rather critical. The rate of clock one (IC8d) should be as close to 125 Hz as possible (8 ms period), and clock two (IC8e and IC8f) should be similarly set to 40 kHz. Use potentiometer R1

As of the writing of this article, Mountain Hardware Inc (300 Harvey West Blvd, Santa Cruz CA 95060) has announced a plug-in card for the Apple II that, like the control card described in this article, transmits to the BSR X-10 Command Console. In addition, the company offers control software tailored to the Apple II with at least 32 K bytes of programmable memory. Cost of the unit is $189 for the controller board alone and $279 for the controller board, the X-10 Command Console, and three remote modules.

The following items are available from:
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4. *Cable and adapter board for S-100 bus $34.95*
5. *0.5 A power supply $9.95*

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Number	Type	+5V	GND
IC1	74150	24	12
IC2	74150	24	12
IC3	7408	14	7
IC4	7404	14	7
IC5	7451	14	7
IC6	74123	16	8
IC7	7493	5	10
IC8	7404	14	7
IC9	74LS02	14	7
IC10	74LS30	14	7
IC11	74LS75	5	12
IC12	74LS75	5	12
IC13	74LS04	14	7

Figure 4: *An interface between the computer and the wireless remote control. Control of AC appliances is as simple as a single BASIC command. Potentionmeter R1 is set for 4 ms, R2 is set for 1.2 ms, and R3 is set for 40 kHz. The output transducer is typically a MASSA Products TR-89 set for 40 kHz center frequency. A 23 kHz transducer should not be used. The effective range is 20 feet. The circuit requires approximately 300 mA at +5 V. Pin designations are for the TRS-80.*

REAL-TIME CLOCK (OPTIONAL) ↔ MICROCOMPUTER (APPLE, TRS-80 ETC.) → WIRELESS REMOTE CONTROL INTERFACE (FIGURE 4) → 40 kHz TRANSDUCER

COMMAND MODULE ← 1 TO 20 FEET → 40 kHz TRANSDUCER

TYPICAL PLACEMENT OF 16 RECEIVERS AROUND THE HOME

#	Module	Location
#1	AM	CIRCUIT CELLAR ACCESSORIES PLUG
#2	LM	CIRCUIT CELLAR TABLE LAMP
#3	WS	CIRCUIT CELLAR STAIR CASE
#4	WS	CIRCUIT CELLAR HALL LIGHT
#5	LM	MASTER BEDROOM TABLE LAMP
#6	LM	SPARE BEDROOM LIGHT
#7	AM	STEREO
#8	AM	GARAGE CAR HEATER
#9	WS	PORCH LIGHT
#10	AM	DEHUMIDIFIER
#11	AM	MASTER BEDROOM TV
#12	WS	OUTSIDE LIGHT #1
#13	WS	OUTSIDE LIGHT #2
#14	WS	OUTSIDE LIGHT #3
#15	WS	GARAGE LIGHT
#16	LM	KITCHEN

EXISTING 115 VAC HOUSE WIRING

LM - LAMP MODULE
WS - WALL SWITCH
AM - APPLIANCE MODULE

Figure 5: *A typical application of the wireless remote control. All of the modules are connected over the house wiring.*

to set the monostable multivibrator (or one-shot) IC6a to a period of 4 ms. Use R2 to set the one-shot IC6b to 1.2 ms.

The output of IC5 should generate the first eleven segments of the message. IC2, using the same technique as IC1, adds a 16 ms end-of-message tone burst as segments 12 and 13. The message is repeated in 24 ms as the counter (IC7) loops to 0. It will send the same data as long as the contents of ICs 11 and 12 have not changed and the output-enable line has not been brought high.

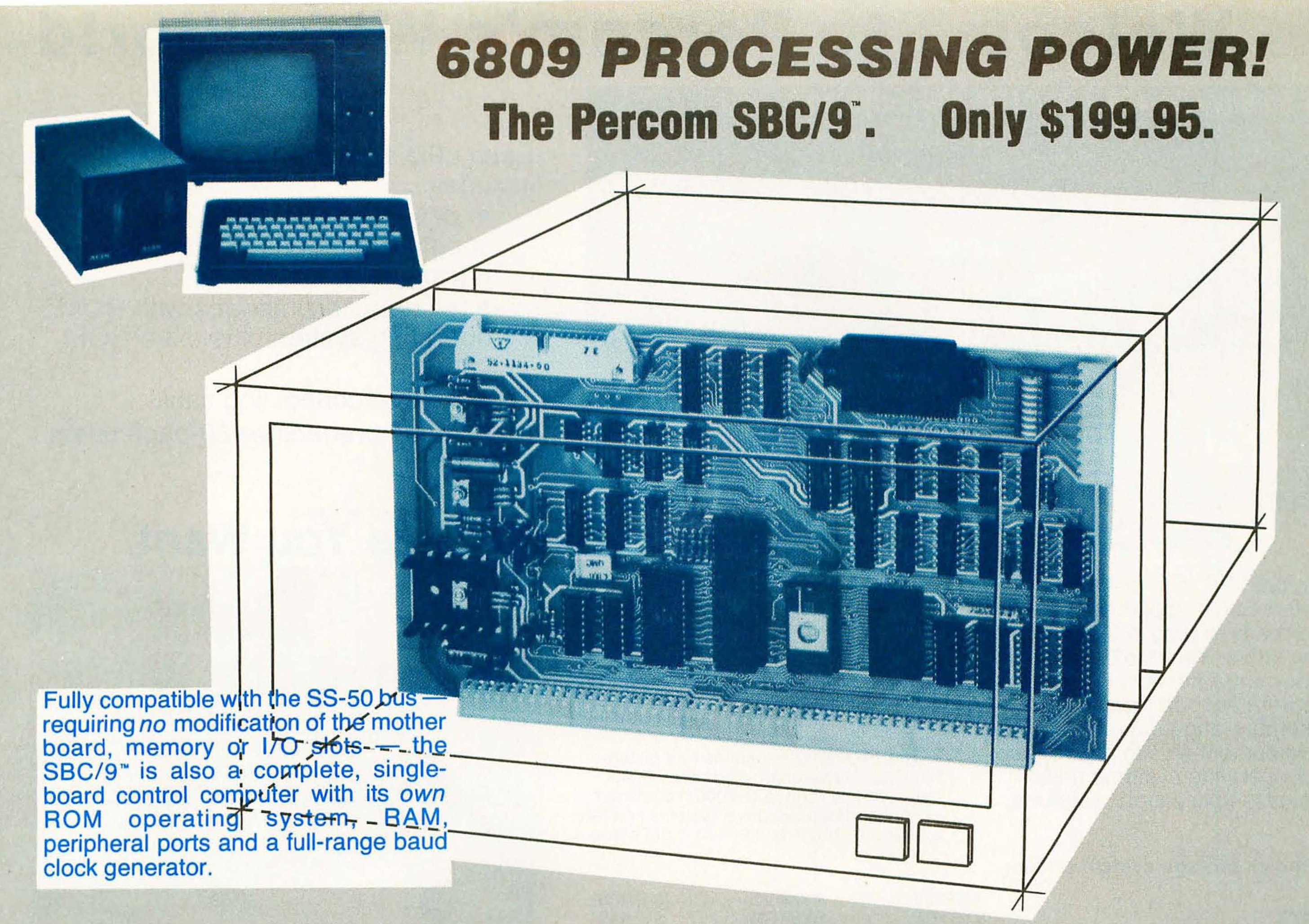
All of the components (except possibly the 40 kHz transducers) are readily available. Low-power Schottky transistor-transistor logic (TTL) devices should be used where specified to properly interface with the TRS-80 or similar low-power bus systems.

One further note for prospective TRS-80 circuit builders. To use this

Text continued on page 48
Listing 1 on page 46

6809 PROCESSING POWER!

The Percom SBC/9™. Only $199.95.



Fully compatible with the SS-50 bus — requiring *no* modification of the mother board, memory or I/O slots — the SBC/9™ is also a complete, single-board control computer with its *own* ROM operating system, RAM, peripheral ports and a full-range baud clock generator.

Make the SBC/9™ the heart of your computer and put to work the most outstanding microprocessor available, the 6809.

the Mighty 6809

Featuring more addressing modes than any other eight-bit processor, position-independent coding, special 16-bit instructions, efficient argument-passing calls, autoincrement/autodecrement and more, it's no wonder the 6809 has been called the "programmers dream machine."

Moreover, with the 6809 you get a microprocessor whose programs typically use only one-half to two-thirds as much RAM space as required for 6800 systems, and run faster besides.

And to complement the extraordinary 6809, the Percom design team has developed PSYMON™, an extraordinary 6809 operating system for the SBC/9™.

PSYMON™ — Percom SYstem MONitor

Although PSYMON™ includes a full complement of operating system commands and 15 externally callable utilities, what really sets PSYMON™ apart is its easy hardware adaptability and command extensibility.

For hardware interfacing, you merely use simple, specific device driver routines that reference a table of parameters called a Device Control Block (DCB). Using this technique, interfacing routines are independent of the operating system.

The basic PSYMON™ command repertoire may be readily enhanced or modified. When PSYMON™ first receives system control, it initializes its RAM area, configures its console and then 'looks ahead' for an optional second ROM which you install in a socket provided on the SBC/9™ card. This ROM contains your own routines that may alter PSYMON™ pointers and either subtly or radically modify the PSYMON™ command set. If a second ROM is not installed, control returns immediately to PSYMON™

™ trademark of Percom Data Company, Inc.

- Provision for multi-address, 8-bit bidirectional parallel I/O data lines for interfacing to devices such as an encoded keyboard.
- A serial interface Reader Control output for a cassette, tape punch/reader or similar device.
- An intelligent data bus: multi-level data bus decoding that allows multiprocessing and bus multiplexing of other bus masters.
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- On-board devices which are fully decoded so that off-card devices may use adjoining memory space.
- Fully buffered address, control and data lines.

The SBC/9™, complete with PSYMON™ in ROM, 1K of RAM and a comprehensive users manual™ costs just $199.95.

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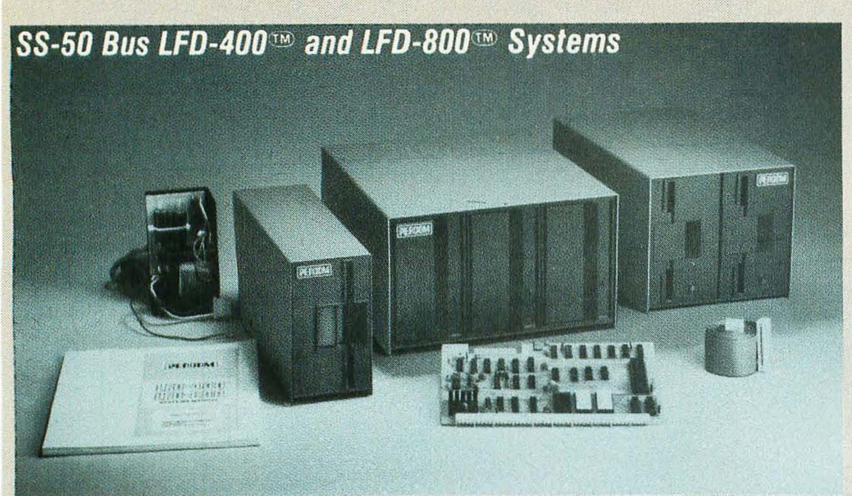
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Circle 25 on inquiry card.

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Welcome to Percom's Wide World



SS-50 Bus LFD-400™ and LFD-800™ Systems

Each LFD mini-disk storage system includes:

- drives with integral power supplies in an enamel-finished enclosure
- a controller/interface with ROM operating system plus extra ROM capacity
- an interconnecting cable
- a comprehensive 80-page users manual

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Low-Cost Mini-Disk Storage in the Size You Want.

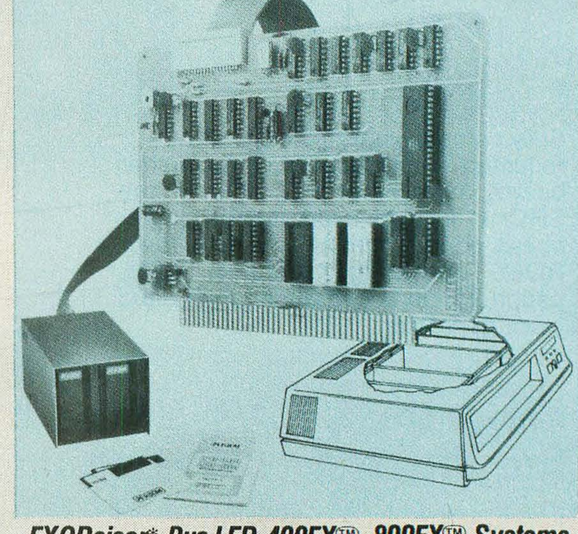
Percom LFD mini-disk drive systems are supplied complete and ready to plug in the moment they arrive. You don't even have to buy extra memory. Moreover, software support ranges from assembly language program development aids to high-speed disk operating systems and business application programs.

The LFD-400™ and -400EX™ systems and the LFD-800™ and -800EX™ systems are available in 1-, 2- and 3-drive configurations. The -400, -400EX drives store 102K bytes of formatted data on 40-track disks, and data may be stored on either surface of a disk. The -800, -800EX drives store 200K bytes of formatted data on 77-track disks.

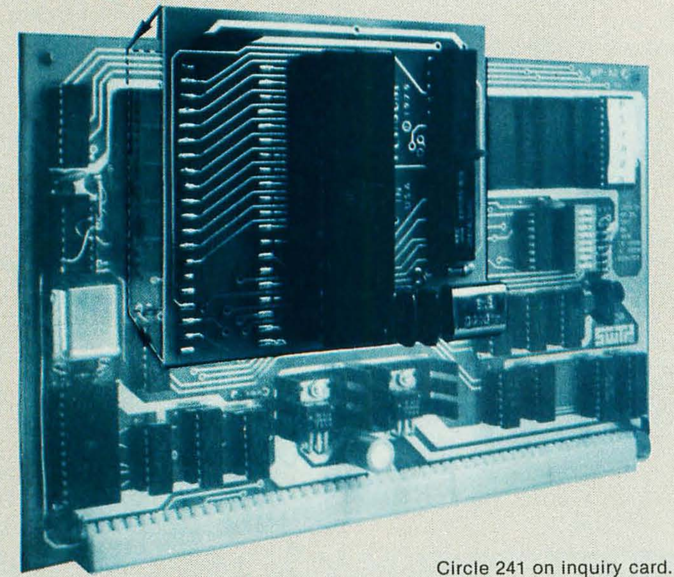
The LFD-1000™ systems (not pictured) have dual-drive units which store 800K bytes on-line. The LFD-1000™ controller accommodates two drive systems so that a user may have as much as 1.6M bytes on-line.

Mini-disk storage system prices:

MODEL	1-DRIVE SYSTEM	2-DRIVE SYSTEM	3-DRIVE SYSTEM
For the SS-50 Bus:			
LFD-400™	$ 599.95	$ 999.95	$1399.95
LFD-800™	895.95	1549.95	2195.95
For the EXORciser* Bus:			
LFD-400EX™	$ 649.95	$1049.95	$1449.95
LFD-800EX™	945.95	1599.95	2245.95
LFD-1000™	(dual) $2495.00	(quad) $4950.00	—



EXORciser Bus LFD-400EX™, -800EX™ Systems*



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Upgrade to 6809 Computing Power. Only $69.95

Although designed with the SWTP 6800 owner in mind, this upgrade adapter may also be used with most other 6800 and 6802 MPUs. The adapter is supplied assembled and tested, and includes the 6809 IC, a crystal, other essential components and user instructions. Restore your original system by merely unplugging the adapter and a wire-jumpered DIP header, and re-inserting the original components. Also available for your upgraded system is PSYMON™ (Percom SYstem MONitor), the operating system for the Percom 6809 single-board computer. PSYMON™ on 2716 ROM costs only $69.95. On diskette (source and object files), only $29.95.

Data Terminal & Two-Cassette Interface — the CIS-30+



Circle 242 on inquiry card.

- Interface to data terminal and two cassette recorders with a unit only 1/10 the size of SWTP's AC-30.
- Select 30, 60 or 120 bytes per second cassette interfacing; 300, 600 or 1200 baud data terminal interfacing.
- Optional mod kits make CIS-30+ work with any microcomputer. (For MITS 680b, ask for Tech Memo TM-CIS-30+-09.)
- KC Standard/Bi-Phase-M (double frequency) cassette data encoding. Dependable self-clocking operation.
- Ordinary functions may be accomplished with 6800 Mikbug* monitor

Prices: Kit, $79.95; Assembled, $99.95. Prices include a comprehensive instruction manual. Also available: Test Cassette, Remote Control Kit (for program control of recorders), IC Socket Kit, MITS 680b mod documentation and Universal Adapter Kit (converts CIS-30+ for use with any computer).

of 6800 Microcomputing.

6800/6809 SOFTWARE

System Software

6800 Symbolic Assembler — Specify assembly options at time of assembly with this symbolic assembler. Source listing on diskette $29.95

Super BASIC — a 12K extended random access disk BASIC for the 6800 and 6809. Supports 44 commands and 31 functions. Interprets programs written in both SWTP 8K BASIC (versions 2.0, 2.2 & 2.3) and Super BASIC. Features: 9-digit BCD arithmetic, Print Using and Linput commands, and much more. Price $49.95

TOUCHUP™ — Modifies TSC's Text Editor and Text Processor for Percom mini-disk drive operation. Supplied on diskette complete with source listing $17.95

Operating Systems

INDEX™ — This easy-to-use disk-operating and file management system for 6800 microcomputers is fast. I/O devices are serviced by interrupt request. INDEX™ accesses peripherals the same as disk files — new devices may be added without changing the operating system. Other features: unlimited number of DOS commands may be added • over 60 system entry points • display only those files at or above user-specified file activity level • versions available for SWTP MF-68, Smoke's BFD-68 and Motorola's EXORciser*. Price $99.95

MINIDOS-PLUSX™ — An extension of the original MINIDOS™ for LFD-400™ mini-disk systems, MINIDOS-PLUSX™ manipulates files by six-character names. Supports up to 31 files. Resident commands include Initialize, Save, Allocate, Load, Files (directory list), Rename and Delete. Supplied on 2708 ROM with a minidiskette that includes transient utilities such as Copy, Backup, Create, Pack and Print Directory. Price .... $34.95.

PSYMON™ — Percom SYstem MONitor for the Percom single-board/SS-50-bus-compatible 6809 computer accommodates user's application programs with any mix of peripherals **without** modifying programs. PSYMON™ also features character echoing to devices other than the communicating device, sophisticated register and memory dump routines and more. Price (on 2716 ROM) .... $69.95.

WINDEX™ — Described in detail elsewhere on this page.

Business Programs

General Ledger — For 6800/6809 computers using Percom LFD mini-disk storage systems. Requires little or no knowledge of bookkeeping because the operator is prompted with non-technical questions during data entry. General Ledger updates account balances immediately — in real time, and will print financial statements immediately after journal entries. User selects and assigns own account numbers; tailors financial statements to firm's particular needs. Provides audit trail. Runs under Percom Super BASIC. Requires 24K bytes of RAM. Supplied on minidiskette with a comprehensive users manual. Price .... $199.95.

FINDER™ — This general purpose data base manager is written in Percom Super BASIC. Works wth 6800/6809 computers using Percom LFD-400™ mini-disk drive storage systems. FINDER™ allows user to define and access records using his own terminology — customize file structures to specific needs. Basic commands are New, Change, Delete, Find and Pack. Add up to three user-defined commands. FINDER plus Super BASIC require 24K bytes of RAM. Supplied on minidiskette with a users manual. Price $99.95

Mailing List Processor — Powerful search, sort, create and update capability plus ability to store 700 addresses per minidiskette make this list processor efficient and easy to use. Runs under Percom Super BASIC. Requires 24K bytes of RAM. Supplied on minidiskette with a users manual. Price $99.95.

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Disassembler/Source Generator	$30.95
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Disassembler/Trace	$25.95
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SmithBUG** (2716 EPROM)	$70.00

½-Price Special on Hemenway Software!

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MACRO-Relocating Assembler	$ 39.97
Linkage Editor (LNKEDT68)	$ 24.97
Cross Reference utility	$ 14.97

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And 'looking into' is just what you do with the Electric Window™ as you peer right into memory space where characters are being input and manipulated. Display is memory-resident, programmable and generates up to 24 80-character lines.

Other features include:
- standard character generator plus provision for optional special character generator
- dual intensity, high-lighting alphanumeric display
- scrolling by a programmable register • programmable display positioning
- programmable interlaced or non-interlaced scan
- descenders on lower case letters • users manual with application instructions and listing of WINDEX™ driver.



The Electric Window.™ Worth Looking Into. $249.95

WINDEX™ is a fast video display driver program for the Electric Window™. WINDEX™ also features: program and keyboard control of character generators • displayable control characters — under program control • automatic scrolling • a driver routine for the parallel input keyboard feature of the Percom 6809 Single-Board Computer, the SBC/9™ • auto-linking to PSYMON™, the ROM operating system for the SBC/9™ • Prices: ROM version: $39.95; LFD-400™ compatible diskette (source and object files): $29.95. Circle 243 on inquiry card.

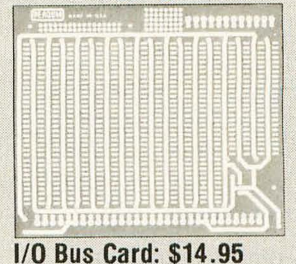
Now Available! the SBC/9™ MPU/Control Computer

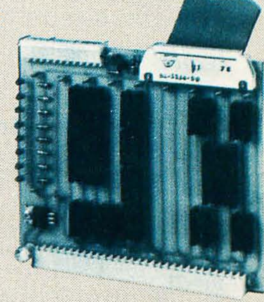
(Single-Board-Computer/6809) — stands alone as a control computer, but also compatible with the SS-50 bus for use as an MPU card. Includes PSYMON™ (Percom SYstem MONitor) in a 1K ROM and provides for additional 1K of ROM. Also includes 1K of RAM. Features: Super Port — provision for multi-address, 8-bit bidirectional data lines • an intelligent data bus for multi-level data bus decoding • an on-board 110-baud to 19.2 kbaud clock generator • extended address capability — to 16 megabytes — without disabling baud clock or adding hardware. And much more. Supplied with PSYMON™ and comprehensive users manual. Price .... $199.95.

See full page ad elsewhere in this magazine for all of the SBC/9™ features. Circle #244.

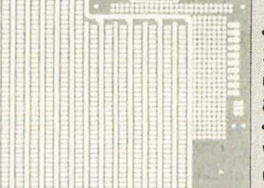
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SS-50 Bus Card: $24.95

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Listing 1: *Demonstration program for the Sears Home Control System.*

```
LIST

90 REM THIS PROGRAM ALLOWS DIRECT COMPUTER CONTROL OVER THE SEARS HOME CONTROL SYSTEM
92 REM
94 REM COPYRIGHT 1979  STEVEN A. CIARCIA
96 REM
98 REM
100 REM SET UP TABLE OF CHANNEL/OUTPUT CODES
105 DIM C(20),S(20)
110 DATA 12,28,4,20,2,18,10,26,14,30
115 DATA 6,22,0,16,8,24
120 FOR X=1 TO 16
125 READ C(X) :REM C(X) IS CHANNEL NUMBER
130 NEXT X
135 GOSUB 200 :GOTO 300
190 REM
195 REM
200 PRINT "CURRENT STATUS IS :"
205 FOR X=1 TO 16
210 PRINT "CHANNEL "$X$" IS  "$ :IF S(X)=1 THEN PRINT"ON" ELSE PRINT"OFF"
220 NEXT X
225 RETURN
300 PRINT "DO YOU WANT TO CLEAR ALL OUTPUTS TO START":INPUT A$
305 IF A$="YES" THEN F=1 :GOSUB 9050:FOR Z=1 TO 16:S(Z)=0 :NEXT Z :REM CLEAR BSR OUTPUTS
310 PRINT "SET CONTROLLER OUTPUTS BY ENTERING CHANNEL NO. AND FUNCTION"
315 PRINT"ENTER CHANNEL NO.      (0 TO EXIT) "$:INPUT C
317 IF C=0 THEN GOSUB 200 :GOTO 300
320 PRINT"CHANNEL "$C$" IS  "$:IF S(C)=1 THEN PRINT"ON" ELSE PRINT"OFF"
325 PRINT"ON,OFF,NEXT,OR REVIEW $":INPUT A$
330 IF A$="ON" THEN S(C)=1:X=C:GOSUB 9000:F=5:GOSUB 9050 :GOTO 315:REM TURN CHANNEL C ON
340 IF A$="OFF" THEN S(C)=0:X=C:GOSUB 9000: F=7:GOSUB 9050 :GOTO 315:REM TURN CHANNEL C OFF
350 IF A$="NEXT" THEN C=C+1:GOTO 320
360 GOSUB 200 :GOTO 315
8996 REM
8998 REM
9000 REM BSR HOME CONTROL DRIVER
9010 REM C(X) IS CHANNEL CODE
9015 OUT 9,C(X) :REM SET CHANNEL
9020 GOSUB 9085
9025 RETURN
9050 REM FUNCTION DRIVER
9060 REM F=FUNCTION CODE
9065 OUT 9,F
9070 GOSUB 9085
9075 OUT 9,128 :REM BIT 7 SHUTS OFF TRANSDUCER OUTPUT
9080 RETURN
9082 REM
9084 REM
9085 FOR Q=0 TO 900 :NEXT Q :RETURN :REM DELAY TIMER

READY
```

```
RUN

CHOOSE ONE OF THE FOLLOWING :

1.  AUTOMATIC CONTROL SYSTEM ON
2.  MANUAL CONTROL / CURRENT STATUS
3.  PRINT THE CURRENT TIME
4.  REVIEW DEFAULT SETTINGS AND ADD TO CONTROL LIST

 YOUR CHOICE ? 4

DO YOU WANT TO REVIEW THE DEFAULT SETTINGS  (Y/N) ? Y
 1 .AT  2  HOURS  0  MINUTES    TURN CHANNEL  10  ON
 2 .AT  17  HOURS  0  MINUTES    TURN CHANNEL  10  OFF
 3 .AT  18  HOURS  30  MINUTES    TURN CHANNEL  6  ON
 4 .AT  19  HOURS  25  MINUTES    TURN CHANNEL  6  OFF
 5 .AT  19  HOURS  40  MINUTES    TURN CHANNEL  6  ON
 6 .AT  20  HOURS  20  MINUTES    TURN CHANNEL  6  OFF
 7 .AT  20  HOURS  35  MINUTES    TURN CHANNEL  6  ON
 8 .AT  21  HOURS  50  MINUTES    TURN CHANNEL  6  OFF
 9 .AT  22  HOURS  0  MINUTES    TURN CHANNEL  6  ON
 10 .AT  23  HOURS  50  MINUTES    TURN CHANNEL  6  OFF
 11 .AT  1  HOURS  50  MINUTES    TURN CHANNEL  6  ON
 12 .AT  2  HOURS  45  MINUTES    TURN CHANNEL  6  OFF
```

Listing 1 continued on page 48

Listing 1 continued:

```
 13 .AT  16  HOURS  0  MINUTES     TURN CHANNEL  1  ON
 14 .AT  22  HOURS  0  MINUTES     TURN CHANNEL  1  OFF
 15 .AT  23  HOURS  0  MINUTES     TURN CHANNEL  4  ON
 16 .AT  0  HOURS  30  MINUTES     TURN CHANNEL  4  OFF
 17 .AT  19  HOURS  30  MINUTES     TURN CHANNEL  5  ON
 18 .AT  21  HOURS  20  MINUTES     TURN CHANNEL  5  OFF
 19 .AT  22  HOURS  0  MINUTES     TURN CHANNEL  5  ON
 20 .AT  1  HOURS  0  MINUTES     TURN CHANNEL  5  OFF

       1......CHANGE LIST
       2......ADD TO LIST
       0......EXIT TO MENU
? 2
 ENTER TIME ,CHANNEL, AND FUNCTION
ENTRY NO. 21   ? 2330,3,ON
ENTRY NO. 22   ? 0,0,0

       1......CHANGE LIST
       2......ADD TO LIST
       0......EXIT TO MENU
? 0


CHOOSE ONE OF THE FOLLOWING :

1.  AUTOMATIC CONTROL SYSTEM ON
2.  MANUAL CONTROL / CURRENT STATUS
3.  PRINT THE CURRENT TIME
4.  REVIEW DEFAULT SETTINGS AND ADD TO CONTROL LIST

 YOUR CHOICE ? 1
AUTOMATIC CONTROL INITIATED
 23 HOURS  43 MINUTES
```

Listing 2: *Program to compare the time from a real-time clock against a list of operations to be performed at specific times. A sample run of the program demonstrates how the entries may be varied.*

```
RUN
CURRENT STATUS IS :
CHANNEL  1  IS  OFF
CHANNEL  2  IS  OFF
CHANNEL  3  IS  OFF
CHANNEL  4  IS  OFF
CHANNEL  5  IS  OFF
CHANNEL  6  IS  OFF
CHANNEL  7  IS  OFF
CHANNEL  8  IS  OFF
CHANNEL  9  IS  OFF
CHANNEL  10  IS  OFF
CHANNEL  11  IS  OFF
CHANNEL  12  IS  OFF
CHANNEL  13  IS  OFF
CHANNEL  14  IS  OFF
CHANNEL  15  IS  OFF
CHANNEL  16  IS  OFF
DO YOU WANT TO CLEAR ALL OUTPUTS TO START
? YES
SET CONTROLLER OUTPUTS BY ENTERING CHANNEL NO. AND FUNCTION
ENTER CHANNEL NO.      (0 TO EXIT) ? 2
CHANNEL  2  IS  OFF
ON,OFF,NEXT,OR REVIEW ;
? ON
ENTER CHANNEL NO.      (0 TO EXIT) ? 5
CHANNEL  5  IS  OFF
ON,OFF,NEXT,OR REVIEW ;
? ON
ENTER CHANNEL NO.      (0 TO EXIT) ? 2
CHANNEL  2  IS  ON
ON,OFF,NEXT,OR REVIEW ;
? NEXT
CHANNEL  3  IS  OFF
ON,OFF,NEXT,OR REVIEW ;
? REVIEW
CURRENT STATUS IS :
CHANNEL  1  IS  OFF
```

Listing 2 continued on page 50

Text continued from page 42:
interface properly, you must have Level 2 BASIC to address output ports. Also, in most Level 2 systems, +5 V on the expansion connector has been disconnected at the factory. It will be necessary, therefore, to provide a separate 5 V 300 mA power supply for the interface electronics.

Using the Interface

A typical application is demonstrated in figure 5. The receivers can be placed around the home to control a variety of appliances and lights. With the addition of the real-time clock outlined in a previous Circuit Cellar article ("Anyone Know the Real Time?" August 1979 BYTE, page 50) you can add timed activation of these control functions as well.

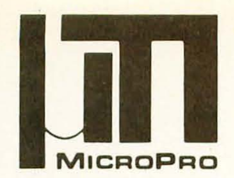
Listing 1 shows a simple BASIC program that demonstrates the interface capabilities. The command console is plugged in and positioned within 20 feet on a direct unobstructed line with the interface output transducer. The program starts by asking if you want to clear all outputs and start fresh. Since the BSR X-10 is an open-loop control system, and you have no way of knowing which receivers are activated, this is a prudent choice.

To turn on channel 6, simply answer the appropriate questions with "6" and "ON". The status of all channels can be reviewed at any time.

The program responds by calling a control output routine. Turning channel 6 on requires two outputs to the command console. One sets channel 6 (as if pressing the 6 button), and the other sets the "on" function (as if pressing the ON button). To allow enough time for the command console to respond, delay loops are inserted. The result is a 2-second signal to set device code 6 and a 2-second message that tells it to turn on. The process can be reversed with a 6 and an OFF program command. All sixteen channels can be just as easily cycled.

Listing 2 is the logical extension of this basic concept. Using a real-time clock, you can create a list of precisely timed events. It can be used to control house lighting during vacations or to turn the coffee maker on at 6:30 AM. The program incorporates a default list of data statements. Each statement is formatted as time, chan-

Text continued on page 54



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"Professional Quality Software You Can Count On, Now!"

WORD-STAR T.M.

THE BEST GETS BETTER! Yes, in just a few months, thousands of users now know that WORD-STAR™ is the word processing product that truly transforms the performance of Z-80, 8085, and 8080 microcomputers into a class with systems costing far more. Look at these recent enhancements: Print spooling; directory; foreign language adaptability; microspace justification; mailing list merge; CP/M*1.4, 2.0 & MPM compatible, and more. Examine our features and order yours now!

OVERVIEW OF WordStar

WordStar is a screen oriented, CP/M compatible, integrated word processing system specifically designed for non-technical personnel. Text and command functions are fully prompted (4 help levels) and, performed on-screen with complete cursor tracking of all functions. Concurrent printing while editing improves operator productivity.

- **Cursor-tracked Screen Display:** Under user control, the CRT screen acts as a moveable "window" into the text; all key strokes receive immediate visual updating.
- **Automatic Disk Buffering:** Text is moved between disk and CPU memory with no user intervention. Thus, file size is limited only by disk capacity.

On-Screen Printer-Image Text Formatting: Using the default margins or user-set margins, entered text is automatically formed into right and left justified lines. Ragged-right is a user settable option. The Word-Wrap feature means that as you type past the right margin, the word being typed is moved to the left margin on the next line. The previous line is redisplayed, justified! You can change the margin settings and reform (i.e.redisplay all or part of the text with the new settings). Partial remargination allows cutting the text around an illustration or for any other purpose such as this paragraph.

Split-Screen Help Menus: Four user-settable levels provide the learning operator with comprehensive prompting instructions without the need to refer to a manual. Help levels may be changed at any time to allow full screen utilization.

Status Line: Constantly updated, the status line displays page number, cursor line and column, name of file under edit, and command(s), if any, in current operation.

Powerful Editing Commands: include delete character, word, line or block; set/clear variable tab stop; block move, copy, delete and output to disk; **find/replace;** write/read from/to additional files; set/return to place markers; on- screen insert toggle; and **more**.

Dynamic Page Break Display: A horizontal dotted line, not part of the text, is shown on the screen at the point a printer page break would occur. The page break line is dynamically repositioned when text entry or deletion affects page size. Visual edits of a print image allow even an inexperienced operator to perform sophisticated text composition.

WordStar Overview (continued)

Concurrent Print Function: Editing and printing simultaneously.

Pagination and Formatting:

- User overide of default top/bottom margins.
- User overide of page length default.
- Variable heading/footing texts and page number locations.
- Conditional and absolute pagination directives.

Printer Support A wide range of letter quality and line printers are supported including Diablo, Nec, and Qume, as well as teletype compatible printers. Features supported include: bidirectional printing, Underline, Double Strike, **Boldface**, and Strikeout.

Subscripts, Superscripts, Variable Character Pitch: (pica, elite, or your choice of number of characters per inch); **Variable Line Height** (6, 8, or your choice of lines per inch) and Alternate Ribbon Color are fully supported on Diablo, Nec, and Qume printers. Print enhancements may be used in all **combinations.** For example, underlined and boldfaced subscripts are supported.

Microspace Justification: When printing justified text on a daisy wheel printer, the white space in each line is evenly distributed.

WordStar is **compatible** with a wide variety of hardware, and can share files with other software:

CRT Compatibility: WordStar's video edit function will operate, after suitable installation, on **any CRT or video board** 16 x 64, 24 x 80, or larger that has cursor positioning functions and that is accessible as a CP/M console device.

New Features include:

- **Directory display:** Using a **triple split screen** WordStar allows scrolling text, and CP/M file directory independently on screen.
- **Install Program:** generates a version of WordStar for use on most popular terminals and printers without the need for any "patching". Allows full speed, 1200 baud, printer operation.
- **Foreign Language:** As WordStars' menus and messages are mostly external to the operating program they lend themselves to translated versions.

2

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Note: Micro Pro offers a reward for reporting and successful prosecution of unauthorized copying.

Listing 2 continued:

```
CHANNEL  2  IS  ON
CHANNEL  3  IS  OFF
CHANNEL  4  IS  OFF
CHANNEL  5  IS  ON
CHANNEL  6  IS  OFF
CHANNEL  7  IS  OFF
CHANNEL  8  IS  OFF
CHANNEL  9  IS  OFF
CHANNEL  10  IS  OFF
CHANNEL  11  IS  OFF
CHANNEL  12  IS  OFF
CHANNEL  13  IS  OFF
CHANNEL  14  IS  OFF
CHANNEL  15  IS  OFF
CHANNEL  16  IS  OFF
ENTER CHANNEL NO.     (0 TO EXIT) ?


LIST

100 REM
110 REM THIS PROGRAM PROVIDES REAL TIME CONTROL OF AC APPLIANCES
120 REM BY CONNECTING THE SEARS HOME CONTROL SYSTEM AND A REAL TIME CLOCK
130 REM TOGETHER.
140 REM
150 REM COPYRIGHT 1979   STEVEN CIARCIA
160 REM
170 REM
180 GOSUB 350 :REM LOAD DATA TABLES
190 REM PROGRAM OPTIONS ARE MADE THROUGH MENU SELECTIONS
200 PRINT :PRINT: PRINT "CHOOSE ONE OF THE FOLLOWING :"
210 PRINT
220 PRINT"1.  AUTOMATIC CONTROL SYSTEM ON"
230 PRINT"2.  MANUAL CONTROL / CURRENT STATUS
240 PRINT"3.  PRINT THE CURRENT TIME"
250 PRINT"4.  REVIEW DEFAULT SETTINGS AND ADD TO CONTROL LIST"
260 PRINT
270 PRINT" YOUR CHOICE "; :INPUT Z1
280 IF Z1=1 THEN PRINT"AUTOMATIC CONTROL INITIATED" : GOTO 1190
290 IF Z1=2 THEN GOSUB 740 :GOTO 810
300 IF Z1=3 THEN GOSUB 1470 :PRINT :PRINT"THE PRESENT TIME IS "; :GOSUB 1130 :GOTO 200
310 IF Z1=4 THEN GOTO 940
320 GOTO 200
330 REM
340 REM
350 REM SET UP TABLE OF CHANNEL/OUTPUT CODES
360 DIM C(20),S(50)
370 DATA 12,28,4,20,2,18,10,26,14,30
380 DATA 6,22,0,16,8,24
390 FOR X=1 TO 16
400 READ C(X) :REM C(X) IS CHANNEL NUMBER
410 NEXT X
420 REM WHEN PROGRAM IS INITIATED THE FOLLOWING DATA TABLE CONSTITUTES THE DEFAULT CONTROL SETPOINTS
430 REM SETPOINTS ARE STORED AS DATA STATEMENTS IN THE FORM OF TIME,CHANNEL,AND FUNCTION
440 REM W=TOTAL NUMBER OF DATA STATEMENTS
450 REM
460 DIM W(50),A(50),B(50),A$(50),L(50)
470 W=20 :REM W=TOTAL NUMBER OF DEFAULTS
480 DATA 0200,10,"ON" :REM DEHUMIDIFIER
490 DATA 1700,10,"OFF"
500 DATA 1830,6,"ON" :REM SPARE BEDROOM LIGHTS
510 DATA 1925,6,"OFF"
520 DATA 1940,6,"ON"
530 DATA 2020,6,"OFF"
540 DATA 2035,6,"ON"
550 DATA 2150,6,"OFF"
560 DATA 2200,6,"ON"
570 DATA 2350,6,"OFF"
580 DATA 0150,6,"ON"
590 DATA 0245,6,"OFF"
600 DATA 1600,1,"ON" :REM CIRCUIT CELLAR ACCESS. PLUG
610 DATA 2200,1,"OFF"
620 DATA 2300,4,"ON" :REM CELLAR HALL
630 DATA 0030,4,"OFF"
640 DATA 1930,5,"ON" :REM MASTER BEDROOM
650 DATA 2120,5,"OFF"
660 DATA 2200,5,"ON"
670 DATA 0100,5,"OFF"
680 FOR L=1 TO W :READ A(L),B(L),A$(L) :REM SET TIME,CHANNEL,FUNCTION
```

Listing 2 continued on page 52

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240 L.P.M.,
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Dot Matrix, Plotter

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Circle 28 on inquiry card.

Listing 2 continued:

```
690 NEXT L
700 RETURN
710 STOP
720 REM
730 RE197 REM
740 PRINT "CURRENT STATUS IS :"
750 FOR X=1 TO 16
760 PRINT "CHANNEL "; X;" IS  "; :IF S(X)=1 THEN PRINT"ON" ELSE PRINT"OFF"
770 NEXT X
780 RETURN
790 REM
800 REM
810 PRINT "DO YOU WANT TO CLEAR ALL OUTPUTS TO START":INPUT A$
820 IF A$="YES" THEN F=1 :GOSUB 1380:FOR Z=1 TO 16:S(Z)=0 :NEXT Z :REM CLEAR BSR OUTPUTS
830 PRINT "SET CONTROLLER OUTPUTS BY ENTERING CHANNEL NO. AND FUNCTION"
840 PRINT"ENTER CHANNEL NO.     (0 TO EXIT) ";:INPUT C
850 IF C=0 THEN GOTO 200
860 PRINT"CHANNEL ";C;" IS  ";:IF S(C)=1 THEN PRINT"ON" ELSE PRINT"OFF"
870 PRINT"ON,OFF,NEXT,OR REVIEW ;":INPUT A$
880 IF A$="ON" THEN S(C)=1:X=C:GOSUB 1330:F=5:GOSUB 1380 :GOTO 840:REM TURN CHANNEL C ON
890 IF A$="OFF" THEN S(C)=0:X=C:GOSUB 1330: F=7:GOSUB 1380 :GOTO 840:REM TURN CHANNEL C OFF
900 IF A$="NEXT" THEN C=C+1:GOTO 860
910 GOSUB 740 :GOTO 840
920 REM
930 REM
940 PRINT: PRINT"DO YOU WANT TO REVIEW THE DEFAULT SETTINGS  (Y/N) ";:INPUT B$
950 IF B$<>"Y" THEN GOTO 1000
960 FOR L=1 TO W
970 L1=INT(A(L)/100)
980 PRINT L;".";"AT ";L1;" HOURS ";A(L)-L1*100;" MINUTES     ";"TURN CHANNEL ";B(L);" ";A$(L)
990 NEXT L
1000 PRINT:PRINT"      1......CHANGE LIST":PRINT"      2......ADD TO LIST"
1010 PRINT"      0......EXIT TO MENU" :INPUT Z2
1020 IF Z2=0 THEN GOTO 200
1030 IF Z2=1 THEN PRINT"RECORD ENTRY TO BE CHANGED";  ELSE 1080
1040 INPUT Z3
1050 PRINT" PRESENTLY  ";A(Z3),B(Z3),A$(Z3)
1060 INPUT "TIME ,CHANNEL,AND ON OR OFF ";A(Z3),B(Z3),A$(Z3) :IF A(Z3)=0 THEN 1000
1070 PRINT "CHANGE ANOTHER  Y/N "; :INPUT Z$ :IF Z$="Y" THEN GOTO 1030 ELSE 1000
1080 IF Z2<>2 THEN GOTO 1000
1090 REM START ADDITIONS AT END OF DEFAULT LIST
1100 PRINT" ENTER TIME ,CHANNEL, AND FUNCTION"
1110 W=W+1 :PRINT"ENTRY NO.";W,:INPUT A(W),B(W),A$(W) :IF A(W)=0 THEN W=W-1 :GOTO 1000
1120 GOTO 1110
1130 REM 4 DIGIT FORMAT ROUTINE
1140 T2=H1*10+H0 :T3=M1*10+M0
1150 PRINT T2;"HOURS ";T3;"MINUTES" :RETURN
1160 REM
1170 REM
1180 REM
1190 REM CONTROL OUTPUT SUBROUTINE----SETPOINT MONITOR
1200 T5=0
1210 GOSUB 1470  :REM GET TIME
1220 IF T1<>T5 THEN GOSUB 1130 :T5=T1 :REM PRINT TIME
1230 FOR L=1 TO W
1240 IF T1=A(L) THEN X=B(L) :GOSUB 1330 :GOSUB 1280
1250 NEXT L
1260 IF INP(0)<>0 THEN GOTO 200 :REM CHECK KEYBOARD FOR INTERRUPT INPUT
1270 GOTO 1210
1280 IF A$(L)="ON" THEN F=5:S(B(L))=1  :GOSUB 1400
1290 IF A$(L)="OFF" THEN F=7 :S(B(L))=0 :GOSUB 1400
1300 RETURN
1310 REM
1320 REM
1330 REM BSR HOME CONTROL DRIVER
1340 REM C(X) IS CHANNEL CODE
1350 OUT 9,C(X) :REM SET CHANNEL
1360 GOSUB 1460
1370 RETURN
1380 REM FUNCTION DRIVER
1390 REM F=FUNCTION CODE
1400 OUT 9,F
1410 GOSUB 1460
1420 OUT 9,128 :REM BIT 7 SHUTS OFF TRANSDUCER OUTPUT
1430 RETURN
1440 REM
1450 REM
1460 FOR Q=0 TO 900 :NEXT Q :RETURN :REM DELAY TIMER
```

Listing 2 continued on page 54

Listing 2 continued:

```
1470 REM THIS ROUTINE IS THE REAL TIME CLOCK INTERFACE DRIVER
1480 REM HARDWARE DESCRIBED IN AUG. '79 BYTE
1490 REM IT READS IN 2400 HR. FORMAT AND IS CONNECTED TO PORT 8
1500 RO=0 :OUT 3,254 :REM TURN ON PANEL LIGHT
1510 OUT 8,1 :OUT 8,0 :T=INP(8) :D=T AND 16
1520 IF D=16 THEN 1530 ELSE 1510
1530 MO=T AND 15 : GOSUB 1630
1540 M1=T AND 15 :GOSUB 1630
1550 HO=T AND 15 :GOSUB 1630
1560 H1=T AND 15 :GOSUB 1630
1570 T1=(H1*10+HO)*100+(M1*10+MO) :REM TIME IN 2400 FORMAT
1580 IF RO=T1 THEN 1590 ELSE RO=T1 :GOTO 1510
1590 OUT 3,255 :REM TURN OFF PANEL LIGHT
1600 RETURN
1610 REM T1=TIME    H1=TENS OF HOURS    HO=HOURS
1620 REM M1=TENS OF MINUTES    MO=MINUTES
1630 OUT 8,1 :OUT 8,0 :T=INP(8) :RETURN

READY
```

Text continued from page 48:

nel, and function. To turn on a coffee maker connected to a unit 6 appliance module simply write: DATA 0630,6, "ON". This technique allows us to set up a specific vacation or holiday repertoire. Just load the program and run it. The list of control data can be added to while the program is running. This allows specific actions such as shutting off the television at 2 AM in case you fall asleep during the late show. Entries such as these are retained only as long as the program is running. They must be reentered if the BASIC program is terminated.

Conclusion

I always try to present interfaces and applications that I think will interest BYTE readers. I consider this one is particularly significant considering the cost advantages over earlier technology. I will not replace the relay-controlled lighting in my home, but further expansion of AC control will use the hardware from this article. There are, of course, many situations where the BSR X-10 is inappropriate, but considering the sophistication when it is connected to a computer, I am going to look a lot harder for ones that apply.

Next Month:

It is getting a little cold in Connecticut, and Venezuela is our oil connection. As a result, I have installed a wood stove and have eight cords of wood piled up in the backyard. Realize that not just *any* stove can be put in the Circuit Cellar, so next month I will discuss my "Computer-Controlled Wood Stove."■

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And may the juiciest application win.

apple computer

Circle 31 on inquiry card.

A Computer-Controlled Light Dimmer

Part 1: Design

John H Gibson
Physics Department
Alma College
Alma MI 48801

Microcomputer hobbyists are generally and loosely classified as either software or hardware types, depending on where their dominant interests and fascinations lie. Software types find data manipulation a satisfying end in itself. They dream of ever-expanding memories, and they use their computers to organize their finances, keep kitchen records, and play complex video games. Hardware types look for ever more interesting ways to interface their microcomputers with the outside world. They lie awake at night devising new ways of making their computers control lights, appliances, and mechanical devices. Their homes are filled with wires, relays, and remote sensors.

I am a hardware type. I love to make electrical and mechanical devices respond to automatic control. My most recent interest, which I would like to share with you, has been in using a very simple microcomputer for lighting control.

Of all the control techniques developed by the microcomputer hobbyist, lighting control has remained the most primitive. Until recently, lighting control with a microcomputer was usually restricted to simple on and off switching. *Proportional control,* the controlled dimming of lights, required either expensive hardware or an impractically large software overhead and was therefore beyond the reach of most microcomputer hobbyists.

The recent appearance of peripheral programmable timers for microcomputers has changed all of this. Proportional lighting control with a microcomputer is now both inexpensive and easy to achieve.

Introduction to AC Phase Control

In traditional designs, lamp dimmers used either a rheostat to regulate the current through the lamp, or an autotransformer to adjust the voltage across it. Either of these inherently analog devices requires that a knob be turned to change the lamp brightness, and neither device is amenable to microcomputer control.

Modern lamp dimmers use the technique of *proportional AC phase control.* A semiconductor switch in series with the lamp is opened and closed 120 times per second. The switch's operation is timed to permit a current to flow through the lamp only during a controlled fraction of each half cycle of the 60 Hz alternating voltage supplied by the power line. Because this is a switching process, it is inherently digital, and it is therefore a ready candidate for microcomputer control.

The switching device most commonly used for AC phase control is the *triac.* A triac is a semiconductor device that functions as a *latching switch.* Once turned on, the triac remains on and cannot be turned off until the current through it drops to zero.

Figure 1a is a drawing of a triac, and figure 1b shows its schematic symbol. The terminals through which the switched current flows are labeled *MT1* (main terminal 1) and *MT2* (main terminal 2). A third terminal, called the *gate,* is used to turn on the triac, that is, to establish conduction between main terminal 1 and main terminal 2. Because of its latching property, once the triac is turned on by the gate, it remains on until the current through main terminal 1 and main terminal 2 drops to zero.

Figure 2 illustrates the basic switching arrangement for AC phase control. A triac and a lamp are connected in series with the 120 V, 60 Hz AC power line. A mechanical push-button switch in series with the triac's gate is pushed and released 120 times per second, or once during each half cycle of the 60 Hz alternating voltage applied to the triac and lamp.



Circle 32 on inquiry card.

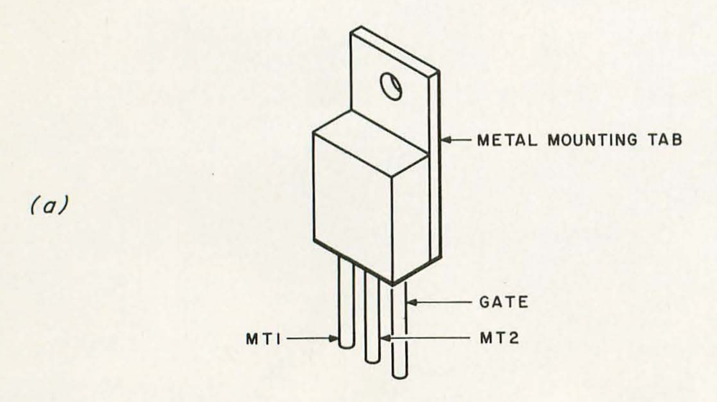




Figure 1: *Sketch of triac (1a) and schematic symbol for a triac (1b).*

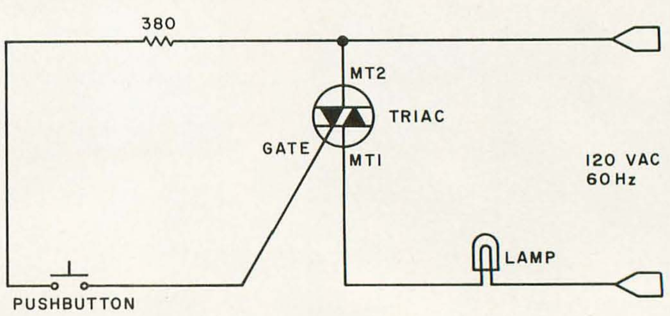


Figure 2: *Basic switching arrangement for proportional AC phase control using a triac.*

At the beginning of each AC half cycle, the triac does not conduct, so no current flows through it and the lamp. Then, a momentary (30 μs) closure of the push-button switch sends a current pulse into the triac's gate. This current pulse turns on the triac, establishing conduction between main terminal 1 and main terminal 2.

Because the triac is a latching switch, it then remains on (even though the push button is released) until the end of the AC half cycle, when the current through it drops to zero. The triac then turns off and remains off until the next momentary closure of the push-button switch.

The 380 ohm resistor limits the gate current pulse to a value that will not damage the triac's gate.

Figure 3 illustrates when the current does and does not flow through the lamp during each AC half cycle. In this illustration, the push-button switch is open (and the triac off) for the first 5 ms of the 8.33 ms (1/120 second) positive half cycle. The push button is then momentarily closed.

At this time the triac turns on, and current flows through it and the lamp until the end of the positive half cycle, when the current drops to zero. The triac then turns off and remains off until the next momentary closure of the push button. The next push-button closure occurs during the negative half cycle, when the triac again turns on and remains on until the negative half cycle ends.

Current therefore flows through the lamp for only a fraction of each AC half cycle. The size of that fraction depends on how late in each half cycle the push button is momentarily closed and the triac turned on. The longer the delay in turning on the triac during each half cycle, the less power will be supplied to the lamp.

The simplified switching arrangement of figure 2 is for illustration only. Obviously, no mechanical switch can be pushed and released with the speed and timing accuracy needed to make this a reliable way of achieving proportional phase control of the power supplied to the lamp.

This does not mean that it is difficult to design circuits that will deliver properly timed trigger pulses to a triac. Many analog circuits that do this can and have been designed. They range in complexity from simple, manually adjusted resistor/capacitor phase-shift networks used in household lamp dimmers to sophisticated ramp-and-pedestal circuits that provide AC phase con-

trol in response to an input analog voltage level.

Unfortunately, none of these analog circuits is easily controlled by a microcomputer. For microcomputer control, something entirely different is needed.

Computer Control of the Triac

To begin, consider how to connect a microcomputer to a triac. Figure 4 shows a simple circuit for coupling a microcomputer's output to a triac's gate. The coupling device is a Motorola MOC3011 optically isolated triac driver. It consists of a light-emitting diode (LED) and an optically coupled *silicon bilateral switch* (SBS).

In operation, each microcomputer-generated current pulse through the LED produces a flash of light that trig-

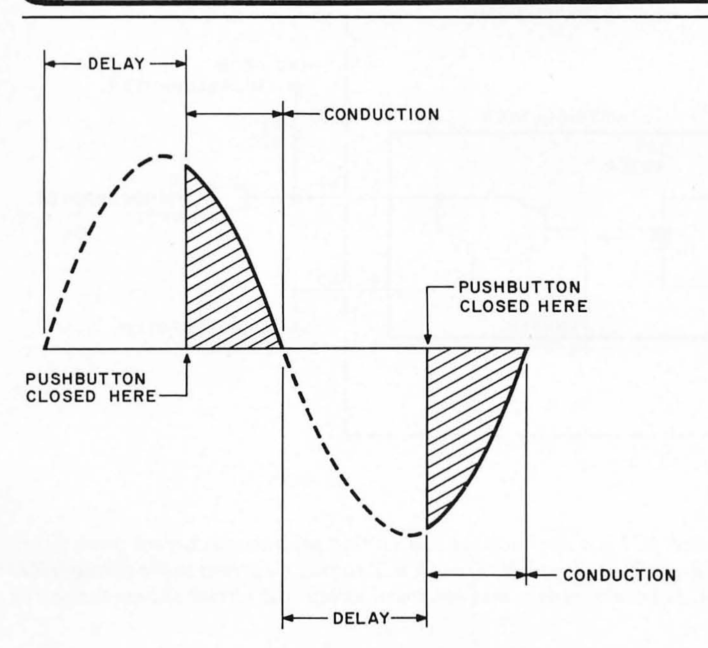


Figure 3: *Graph of the current flowing through the triac and lamp. During each AC half cycle, the current begins to flow when the push-button switch is momentarily closed and continues to flow until the current drops to zero. This example shows the push-button switch closed approximately 5 ms after the beginning of each 8.33 ms AC half cycle.*

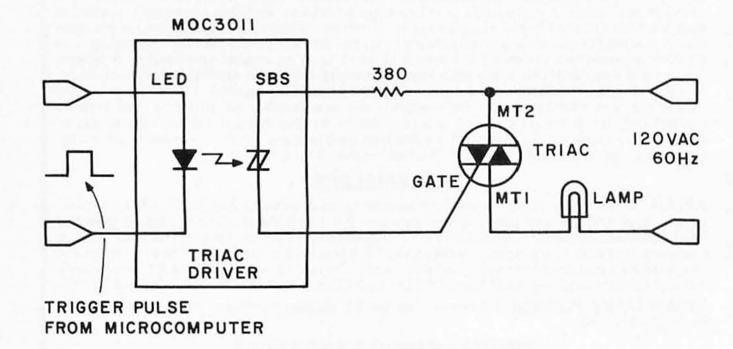


Figure 4: *Electrical isolation between the computer and the triac is achieved with a device containing an LED and a silicon bilateral switch (SBS).*

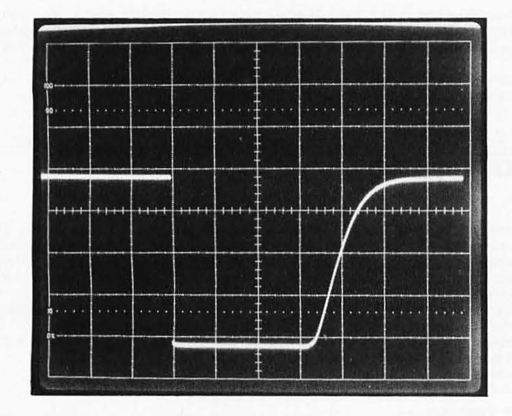


Photo 1: *Output of the synchronizer. The waveform was recorded with a vertical scale factor of 1V per division and a horizontal time base of 100µs per division. Its zero is at the bottom line of the screen.*

gers the silicon bilateral switch into momentary conduction. This sends a current pulse into the triac's gate, turning on the triac for the rest of that AC half cycle. The circuit operates just like the push-button circuit described earlier, except that the push button has been replaced by the silicon bilateral switch, and the triac is now turned on by each microcomputer-generated current pulse.

Electrical isolation is an important feature of this circuit. The MOC3011 permits the microcomputer to control the 120-VAC lamp circuit while remaining electrically insulated from it.

How is the microcomputer to generate the properly timed pulses needed to control the triac? Proportional AC phase control requires 120 pulses per second, with each pulse occurring at a controlled delay interval after the beginning of an AC half cycle. Part of this pulse generation can be performed by software, but there is also an important hardware requirement. The microcomputer can produce properly timed pulses only if it knows *when* each AC half cycle begins. That is, the microcomputer must be *synchronized* to the AC power line.

This design problem has a two-step solution. The steps are:

1. Design a circuit that generates a pulsed logic-level change at the beginning of each AC half cycle.
2. Use this pulsed logic-level change to signal the microcomputer at the beginning of each AC half cycle.

Figure 5 shows a synchronizing circuit that achieves the goal of step 1. The circuit's output remains at logic 1 (5 V), except when it goes to logic 0 for about 0.4 ms at the beginning of each AC half cycle. This output is the

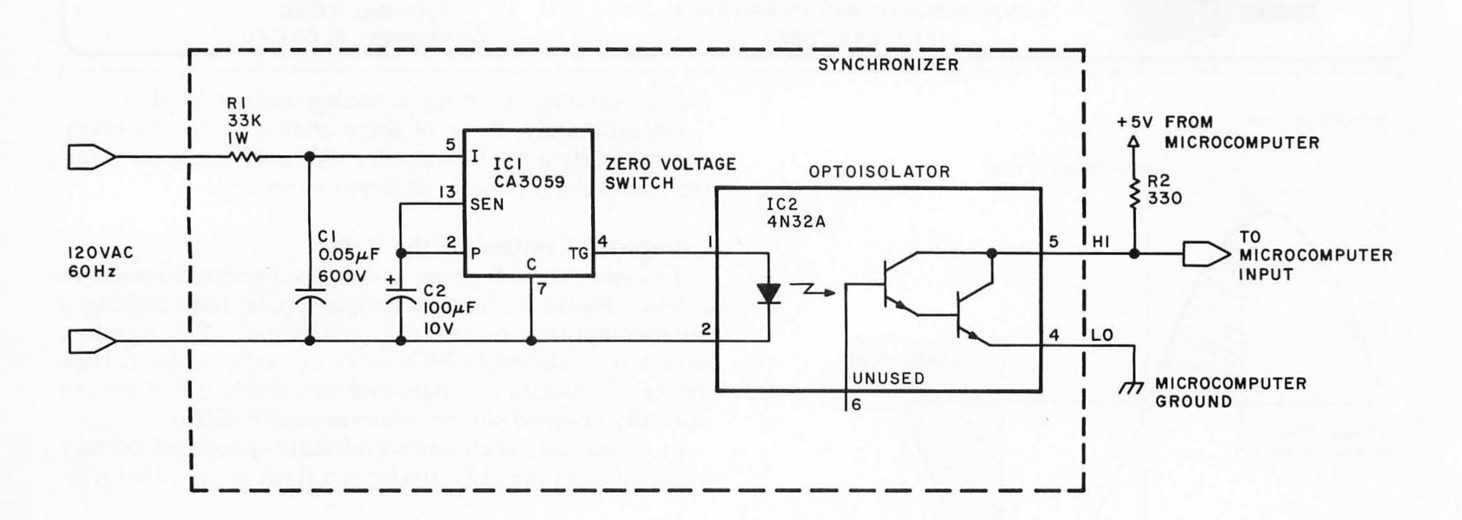


Figure 5: *Synchronizer necessary to provide correct timing reference. IC1 is a zero voltage switch that produces a current pulse (from pin 4) at the beginning of each AC half cycle. This current pulse is optically coupled through IC2 to pull a current pulse through R2, thus generating a momentary logic 0 at the synchronizer's output. For convenience and electrical safety, the circuit shown inside the dotted line should be built into a protected, insulated enclosure.*

Circle 240 on inquiry card.

pulsed logic-level change required.

How is the microcomputer signaled, as required by step 2? The answer to that question depends on how you plan to complete the design of the AC phase control.

One method is to connect the synchronizing signal to one of the microcomputer's interrupt inputs. Upon receipt of each interrupt, the computer enters a program-timing loop to count off the desired delay. At the end of the delay, the program generates an output pulse to trigger the triac and then waits for the next synchronizing interrupt.

An interrupt-driven microcomputer using program-timing loops can handle very simple AC phase control applications, but this scheme becomes unworkable for even moderately sophisticated programs. This is because a wide-range power control capable of adjusting a lamp from complete darkness to full brightness requires a timing loop that runs nearly the full duration of each AC half cycle, leaving almost no time to execute the rest of the program.

It would be much easier to let the microcomputer simply compute a *number* representing the delay time required and leave it to a peripheral timing device to actually count off each delay time and trigger the triac.

Now such a peripheral timing device will be discussed.

The Programmable Timer

A *programmable timer* is a peripheral device designed for connection to the microcomputer bus. It can be configured (by software) so that, driven by an external signal (ie: the synchronizing signal discussed earlier), it generates an output pulse after each input pulse. It accomplishes this with the interval between input and output pulses equal to a *programmed* delay.

This is just what is necessary for an AC phase control. A programmable timer can relieve the microcomputer of all the processing required for delay timing and output pulse generation. With a programmable timer attached, the microcomputer is free to run sophisticated programs that need only load the timer with a new delay number each time a changed delay time is required.

To gain a closer look at the timer's operation, a simplified model will now be examined.

Figure 6 is a diagram of such a timer. In addition to its connections to the microcomputer bus, this timer also has a gate input $\overline{G}$ and an output O. Inside the timer are three addressable registers. They are:

- an 8-bit, write-only *control register* used to establish the timer's operating mode (much as a control register configures the operation of a peripheral interface adapter (PIA));
- a 16-bit, write-only *latch*. Its contents are divided into two 8-bit bytes, called M, for the most significant byte, and L, for the least significant byte. These two bytes are placed in the latch by the program running in the microcomputer, and they may be changed by the program at any time;

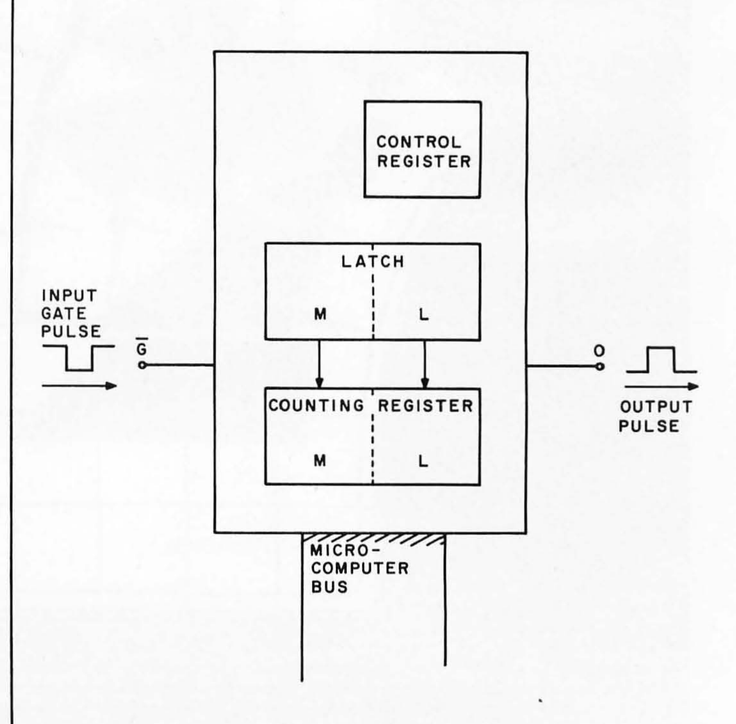


Figure 6: *Model of the programmable timer, showing gate input* $\overline{G}$, *output O, the connection to the microcomputer bus, and the addressable registers. The arrows pointing from the latch to the counting register indicate the data transfer that takes place at the beginning of each count.*

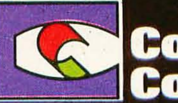
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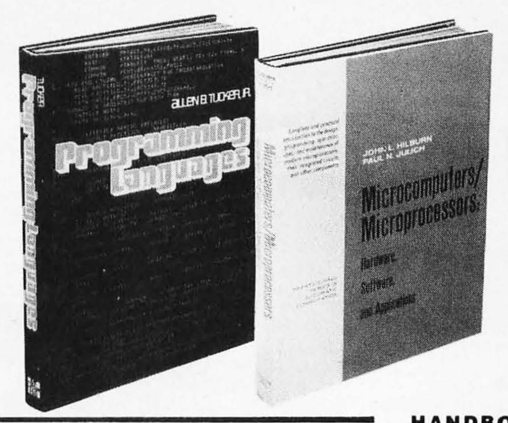


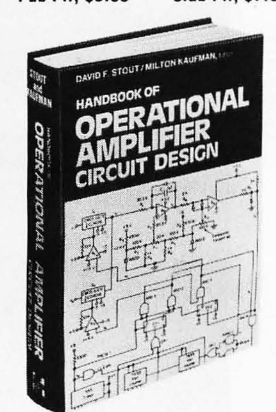
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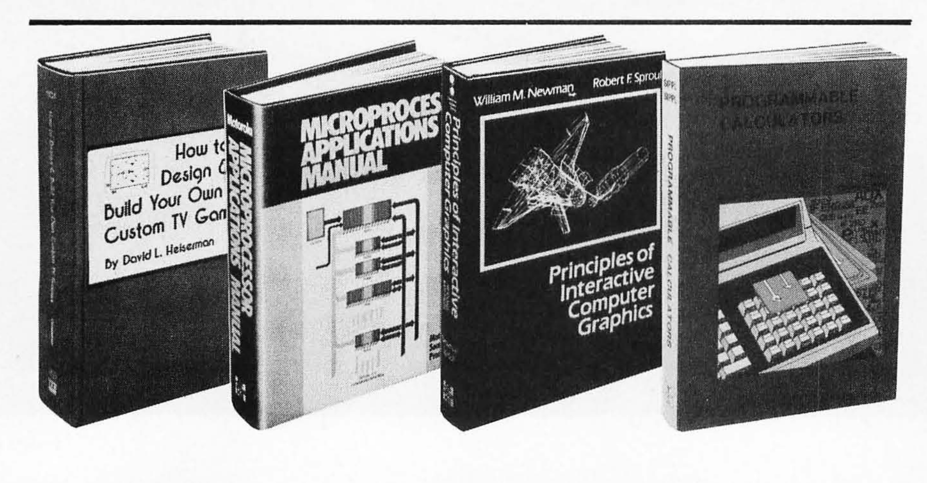
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- a 16-bit, read-only *counting register*. A momentary logic 0 at the timer's gate input causes this register to be loaded with bytes M and L from the latch. The counting register then decrements on each cycle of the microprocessor clock. When the count reaches zero, a voltage pulse is delivered to the timer's output. Details of this operation will be described shortly.

For this application, the synchronizing signal should be connected to the timer's gate, and the timer's output used to trigger the triac.

Now examine the timer in detail by stepping through one cycle of its operation:

1. Upon receipt of a momentary logic 0 at its gate, the timer loads its counting register from the latch (without changing the number stored in the latch). If it is not already low (logic 0), the timer's output goes low.
2. The output remains low for an interval equal to (M+1)L + 1 periods of the microprocessor's clock. At the end of this interval, the timer's output goes high (logic 1).
3. The output remains high for L periods of the microprocessor's clock. At the end of this time, the output again goes low.
4. The output remains low until another momentary logic 0 at the gate starts the cycle again.

This timing sequence is illustrated in figure 7 and example outputs are shown in the photo 2 sequence.

For this application, it is convenient to make L a fixed quantity and let M range from hexadecimal 00 to FF. This choice allows you (1) a fixed output pulse width LT, regardless of the delay chosen, and (2) program control of the timed delay by specification of a single 8-bit byte M.

How is the size of L chosen? The time for one complete cycle of the timer is:

$$\begin{aligned}\text{Timer cycle} &= \text{Delay time} + \text{Output pulse width}\\ &= [(M+1)L + 1]\,T + LT\\ &= (M+1)\,(L+1)T\end{aligned}$$

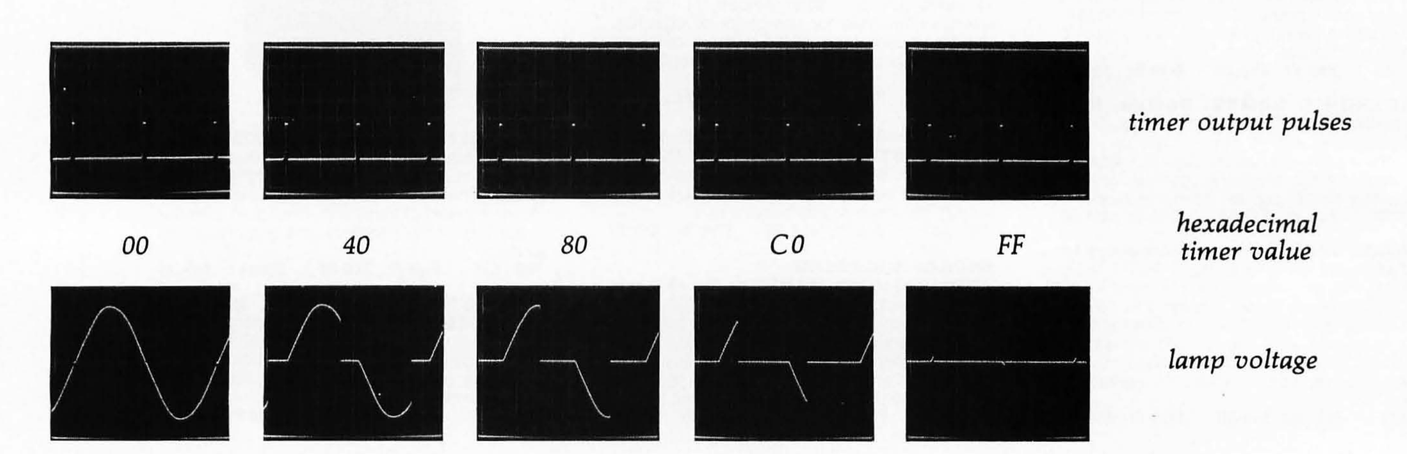


Photo 2: *This series of photos shows how the timer's output pulses lag behind those from the synchronizer and how the alternating voltage across the lamp is determined by the delay value contained in the timer latch. The numbers indicate the hexadecimal value. The top row of photos shows how the timer's output pulses lag those from the synchronizer by a time proportional to the delay value. The synchronizer's output is the series of negative pulses across the top half of the screen, while the timer's output is the series of brief positive pulses (blips) across the bottom half. Both waveforms were recorded with a vertical scale factor of 2V per division and a horizontal time base of 2ms per division. The synchronizer's output has its zero at the screen's horizontal center line, while the timer's zero is at the bottom line.*

The bottom row of photos shows the alternating voltage across the lamp as determined by the delay value in the timer's latch. The waveforms were recorded with a vertical scale factor of 50V per division and a horizontal time base of 2ms per division.

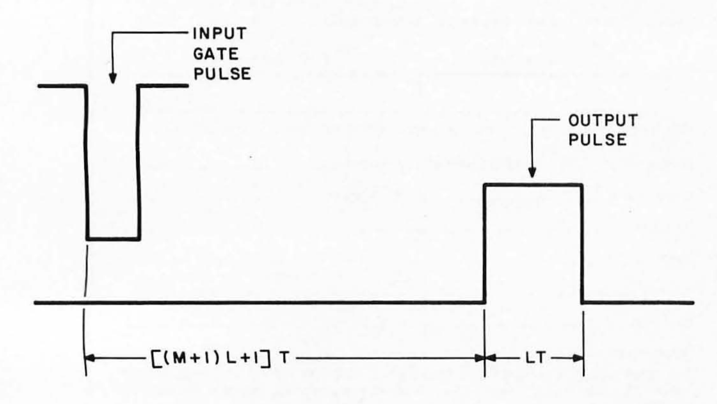
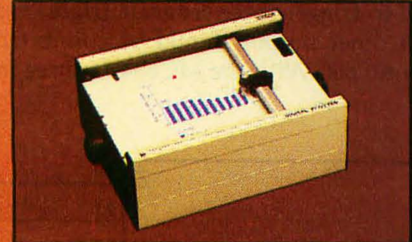


Figure 7: *Timer input and output pulses in the single-shot, dual 8-bit operating mode. The output pulse begins at time t= [(M+1)L+1]T after the input gate pulse, where:*
M= most significant byte loaded from the timer latch into the counting register
L= least significant byte loaded from the timer latch into the counting register
T= period of microprocessor clock

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If the maximum value of M is hexadecimal FF or decimal 255, then the maximum time for one cycle of the timer is:

$$[\text{Timer cycle}]_{max} = 256\ (L+1)\ T$$

Each AC half cycle has a duration of 8333 μs. If you wish one cycle of the timer at maximum delay to just equal one AC half cycle, you must have:

$$8333\ \mu s = 256\ (L+1)\ T$$

which requires that:

$$L = \frac{8333\ \mu s}{256\ T} - 1$$

The value picked for L clearly depends on the period T of the microprocessor clock. For example, if the clock period is 2.5 μs (for a 400 kHz clock), the computed value for L is:

$$L = \frac{8333\ \mu s}{256\ (2.5\ \mu s)} - 1 = 12 = \text{hexadecimal 0C}$$

Using this computed value for L does not work in practice. This is because an intentional, small delay in the synchronizer causes the timed cycle actually to begin about 100 μs after the start of each AC half cycle, thus slightly reducing the time remaining in the half cycle for the timer to operate. However, for this particular example, a value of L = 11 = hexadecimal 0B does work well.

For this example, the timer's output pulse width therefore is:

$$LT = 11 \times 2.5\mu s = 27.5\mu s$$

Programmable Timer Module

Up to now you have been examining a slightly simplified model of the programmable timer. Now concern yourself with a real device, the Motorola MC6840 *programmable timer module*. Figure 8 is a pin-assignment diagram for the MC6840.

Each timer in the MC6840 has its own gate input (pins $\overline{G1}$, $\overline{G2}$ and $\overline{G3}$) and its own output (pins O1, O2 and O3). For this application, the synchronizing signal should be connected to all three gate inputs, and the individual timer outputs used to trigger three separate triacs. Figure 9 shows how *each* timer output should be connected to the AC circuit it controls. With the MC6840's three inde-

Pin	Signal	Signal	Pin
1	V_{SS}	$\overline{C1}$	28
2	$\overline{G2}$	O1	27
3	O2	$\overline{G1}$	26
4	$\overline{C2}$	DØ	25
5	$\overline{G3}$	D1	24
6	O3	D2	23
7	$\overline{C3}$	D3	22
8	$\overline{RESET}$	D4	21
9	$\overline{IRQ}$	D5	20
10	RS0	D6	19
11	RS1	D7	18
12	RS2	ENABLE	17
13	R/$\overline{W}$	CS1	16
14	V_{CC}	$\overline{CS0}$	15

Figure 8: *Pin-assignment diagram for the Motorola MC6840 programmable timer module.*

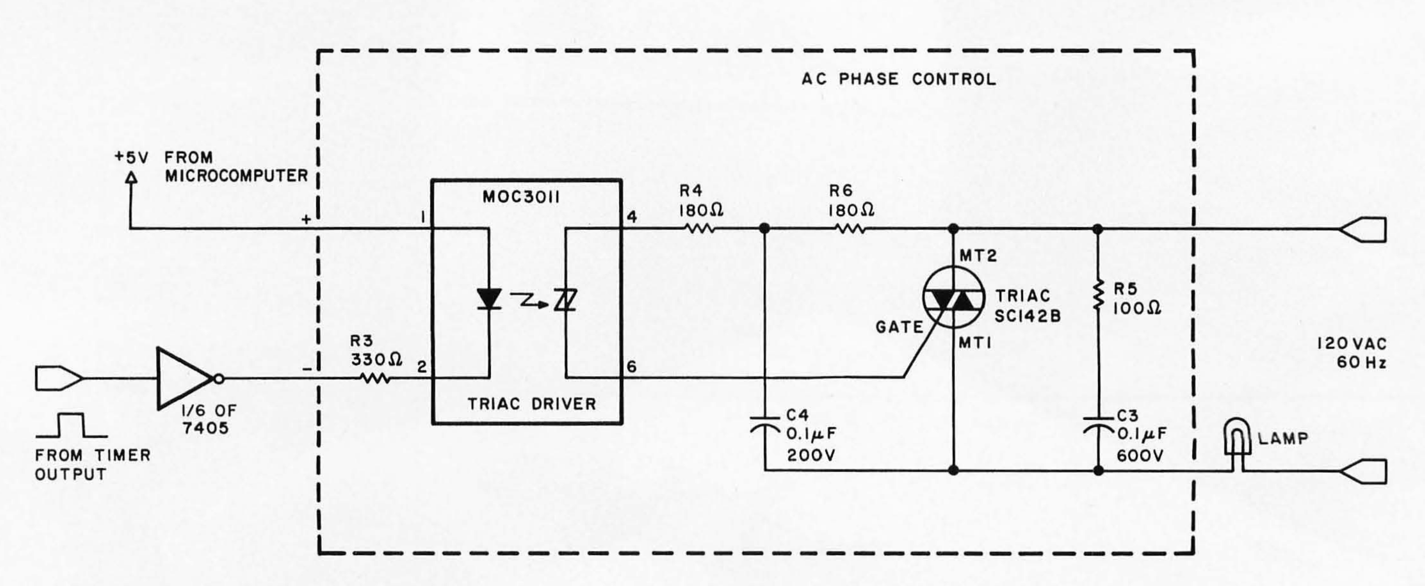


Figure 9: *Circuit for connecting one timer output to the AC circuit it controls. The AC phase-control circuit contained within the dotted lines should be built into a metal box, and the triac's isolated mounting tab securely fastened to the inside wall of the box. (Substitution of a different triac without the isolated mounting feature will require the use of special mounting hardware to electrically isolate the triac from the wall of the enclosure.)*

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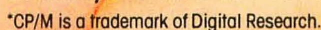
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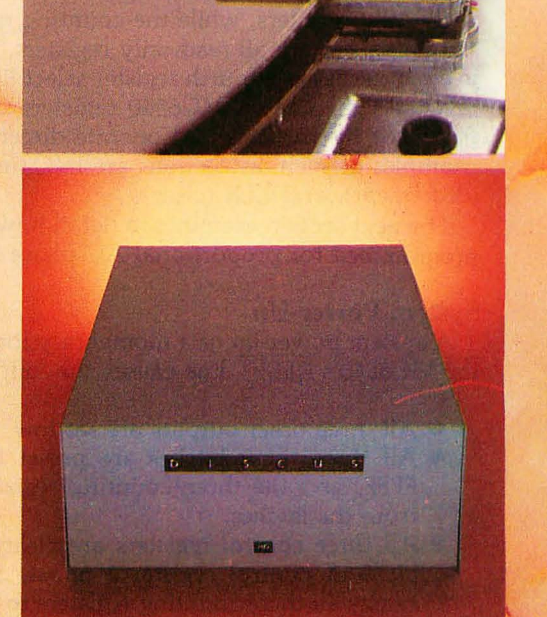
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Register select inputs			Operations	
RS2	RS1	RS0	R/$\overline{W}$ = 0	R/$\overline{W}$ = 1
0	0	0	CR2 bit 0 clear: Write CR3 CR2 bit 0 set: Write CR1	No operation
0	0	1	Write CR2	Read status register
0	1	0	Write M buffer register	Read M of counter 1
0	1	1	Write L of latch 1	Read L buffer register
1	0	0	Write M buffer register	Read M of counter 2
1	0	1	Write L of latch 2	Read L buffer register
1	1	0	Write M buffer register	Read M of counter 3
1	1	1	Write L of latch 3	Read L buffer register

Table 1: *Register selection in the MC6840 programmable-timer module.*

pendent timers, it is possible to control three different AC circuits.

Each timer in the MC6840 also has its own external-clock input (pins $\overline{C1}$, $\overline{C2}$ and $\overline{C3}$) for use when timer-counting frequencies different from that of the microprocessor clock are needed. The external-clock inputs are not needed in this application.

Table 1 describes register selection in the MC6840. The MC6840 contains ten addressable registers. Nine of these are the control registers, timer latches, and counting registers for the three timers. The tenth is a status register containing interrupt flags. The status register will not be used.

The three *register-select inputs* RS0, RS1, and RS2 should normally be connected to the microcomputer's low-order address lines A0, A1, and A2 respectively. Because the control registers and the timer latches are all write-only registers, while the counting registers and the status register are all read-only registers, the R/$\overline{W}$ input in effect serves as a fourth register select line. This feature precludes the use on MC6840 registers of any MC6800 processor instructions that operate directly on memory. Examples of such instructions are INC (increment), DEC (decrement), and CLR (clear).

The next section examines in detail how the MC6840 is programmed for proportional AC phase control.

System Power-Up

A system power-up or a momentary low-logic level on the MC6840's $\overline{\text{RESET}}$ line causes the following actions:

- All three timer outputs are set low.
- All three timer latches are preset to hexadecimal FFFF, and the three counting registers are loaded from the latches.
- All three control registers are cleared, except that bit 0 of control register 1 is set. Setting this bit causes all three counting registers to be held in their preset state, so that the timers do not run.

Timer Initialization

The MC6840 is a versatile device with several operating modes. This application requires that each timer in the MC6840 be configured for single-shot dual 8-bit operation. The MC6840 is initialized for this application by loading hexadecimal B6 into control register 3 (CR3), hexadecimal B7 into control register 2 (CR2), and hexadecimal B6 into control register 1 (CR1).

The order in which these registers are loaded is important. Control registers CR3 and CR1 share a single address space, with bit 0 of CR2 selecting whether control register CR3 or CR1 is accessed (CR2 bit 0 cleared selects CR3; CR2 bit 0 set selects CR1).

For example, if control registers CR3 and CR1 share address hexadecimal 8000 and CR2 occupies address 8001, then (recall that CR2 bit 0 is cleared on system power-up or $\overline{\text{RESET}}$) an appropriate initialization sequence is the following sequence of MC6800 instructions:

```
LDA A  #$B6     Control word for CR3 and CR1
LDA B  #$B7     Control word for CR2

STA A  $8000    Configure timer 3
STA B  $8001    Configure timer 2
STA A  $8000    Configure timer 1
```

Loading the Timer Latches

With the MC6840 initialized and the program running, the brightness of each lamp is controlled by the number stored in its associated timer latch. If not disturbed, these numbers remain unchanged, and the lamps glow with constant brightness. To change the brightness of any lamp, it is necessary only to load a new number into its timer's latch.

It is important that the two bytes of each timer latch be loaded in the proper order. Although table 1 may lead you to believe that the most significant bytes of the three latches have three different addresses, in reality these three addresses lead to a single 8-bit buffer. To load a particular latch, this buffer register must first be loaded with the most significant byte. Then, when the least significant byte is loaded into space L of the latch, the buffer's contents are automatically transferred to the latch's space M.

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320	321	322	323	324
315	316	317	318	319
310	311	312	313	314
305	306	307	308	309
300	301	302	303	304
295	296	297	298	299
290	291	292	293	294
285	286	287	288	289
280	281	282	283	284
275	276	277	278	279
270	271	272	273	274
265	266	267	268	269
260	261	262	263	264
255	256	257	258	259
250	251	252	253	254
245	246	247	248	249
240	241	242	243	244
235	236	237	238	239
230	231	232	233	234
225	226	227	228	229

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For example, suppose the three timer latches occupy hexadecimal addresses 8002 through 8007, and are assigned as follows:

M1: 8002
L1: 8003

M2: 8004
L2: 8005

M3: 8006
L3: 8007

If you wish to load M1, M2, and M3 with new delay numbers DELAY1, DELAY2, and DELAY3 but leave L1, L2, and L3 unchanged with hexadecimal 1E stored in each, the program sequence that would accomplish this is:

```
LDA  A  DELAY1
LDA  B  #$1E
STA  A  $8002
STA  B  $8003

LDA  A  DELAY2
STA  A  $8004
STA  B  $8005

LDA  A  DELAY3
STA  A  $8006
STA  B  $8007
```

It is important to understand that, even though L1, L2, and L3 remain constant, it is not possible to avoid reloading a latch's least significant byte each time you want to change its most significant byte. There is no other way to access the most significant bytes of the timer latches.

Controlled Fading

Proportional AC phase control is most interesting when it is used to fade lamps on and off at controlled rates. This has application to theatrical lighting control, planetarium operation, and control of multiple projectors in a slide show.

Controlled fading may be accomplished by using a program-timing loop to slowly increment or decrement a delay number toward some final value set by the program. The fading stops when the final value is reached. Fading up or down resumes when the program sets a new final value.

The basic timing element can be either the microprocessor's clock or a 120 Hz interrupt signal produced by the synchronizer. Of these two choices, I prefer the latter, simply because it is much slower and therefore easily used to achieve slow fading rates.

But even 120 Hz is too fast. If the delay number is decremented 120 times per second, a lamp fading from complete darkness (DELAY = FF) to full brightness (DELAY = 00) will do so in only 2.1 seconds.

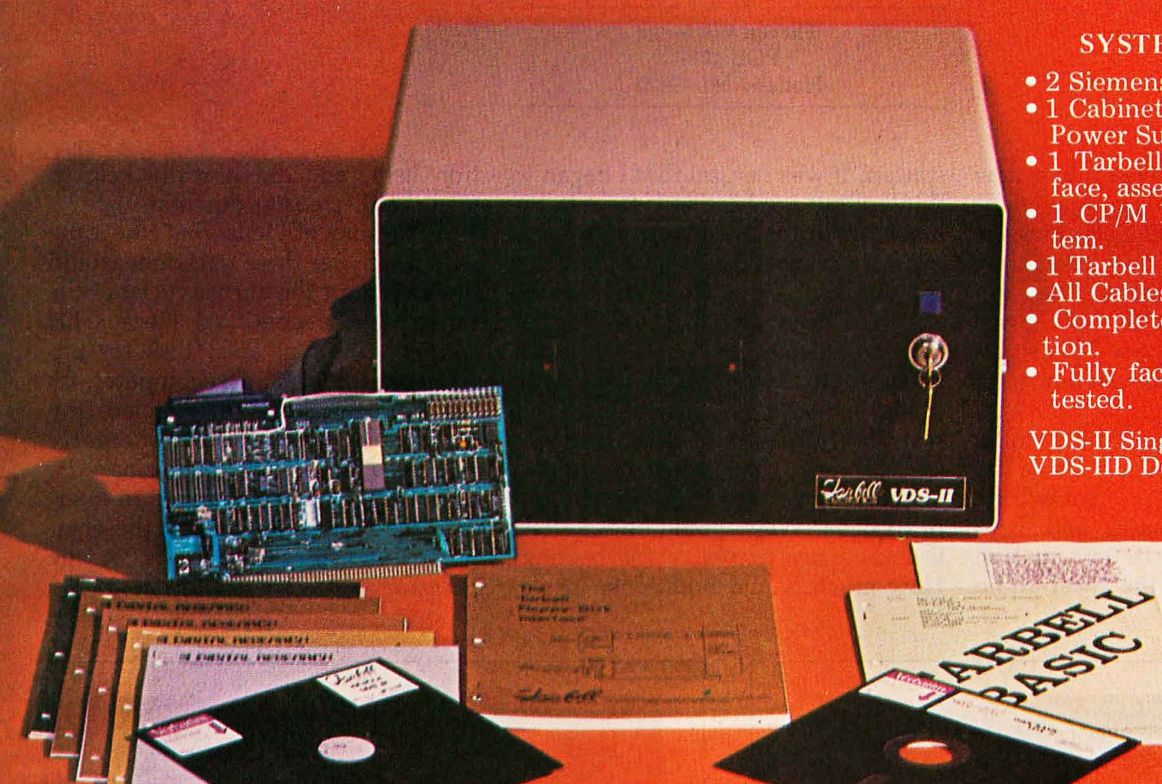
An intermediate register is needed, one which may be incremented or decremented 120 times per second and the carry or borrow generated is used to increment or decrement the delay number.

Summary

You have been introduced to the basic principles of proportional AC phase control; seen how a triac is used for this purpose and how a programmable timer may be used to drive the triac; and looked closely at the Motorola MC6840 programmable timer module configured for this application. A method of using a program timing loop to slowly fade a lamp up and down in brightness has been outlined. You now have all the information necessary to try this on your own.

In part 2 of this article I shall create a program and circuit example on the Heathkit ET-3400 microprocessor trainer that will perform the lighting control functions discussed so far. ■

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With forty-eight km (thirty mile) per hour winds producing 1.8 to 2.4 m (six to eight foot) snowdrifts alongside of the house, and with emergency food source information being broadcast on the local radio station, it was natural that I began to think about the heating system in the house. During a conversation with my wife several questions arose, and we dug out an information booklet that had been supplied with the furnace. We also began to record the furnace on-off cycles.

More questions arose. How long was the burner on? What were the cycle times? How much gas did it burn per cycle, and what was the cost of this gas? What would be the effect if I used my fireplaces for heating? How much would additional insulation help, and did it really help to turn the thermostat down at night?

It became obvious that the only way to answer these questions would be to monitor the burner cycles of the furnace on a continual basis. This seemed to be an ideal task for my homebrew 8080A microcomputer. By the time the storm had ended, my notebook contained schematic diagrams of all the additional circuitry that would be needed to interface the furnace burner to the computer, and the first drafts of the necessary software were written.

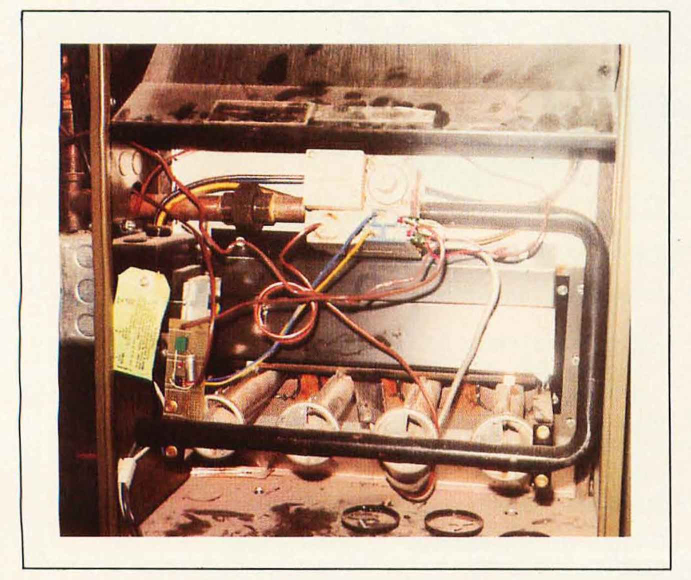


Photo 1: *Interior of the gas furnace. The computer interface circuit board is at the lower left, just to the right of the light green paper tag. The gas solenoid is slightly above the center of the photograph.*

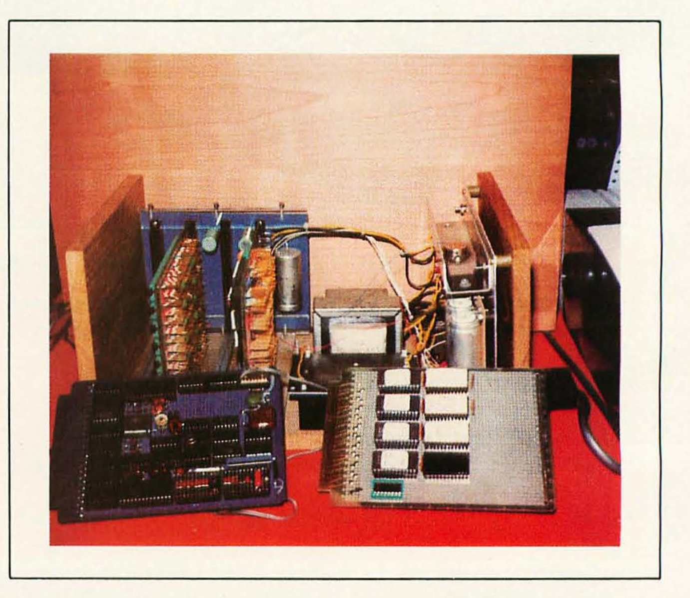


Photo 2: *The author's homebrew 8080A-based microcomputer system. Two circuit boards of interest have been removed from the card cage and are displayed in the foreground. The real-time clock and cassette interface board is on the left; the programmable read-only memory board is on the right.*

About the Author:

Theron Wierenga is a thirty-four-year-old assistant principal at Muskegon High School where he formerly taught physics and computer science. His undergraduate degree in physics is from Hope College, Holland MI. His master's degree is in educational leadership from Western Michigan University.

He has worked during summers at Brookhaven National Laboratory, and for the PLATO group at the University of Illinois at Urbana.

His recreational interests are early US postal history and electronics. He has designed and built many electronic projects, including a homebrew 8080A computer system and an Altair 8800 system. He is presently working on a Mite printer mechanism for a hard copy I/O device. His primary enjoyment comes from building hardware.

Computer

The microcomputer which was used is unique. It was assembled between May 1977 and January 1978, and uses the 8080A microprocessor. The circuitry was packaged on four 4½ by 6 inch (11.43 by 21.24 cm) wire-wrap boards joined by a motherboard using standard 44-pin double readout edge connectors on 0.156 inch (0.402 cm) centers. The four boards consist of:

8080A central processor, bus drivers, and a serial I/O (input/output) port using the Intel 8251 programmable communication interface.

4 K byte programmable memory using 21L02-type static memory devices.

8 K byte programmable read-only memory using Intel 2708 circuits.

Real-time clock, Kansas City format cassette interface, and a parallel I/O port.

After some effort and a little hair pulling, it was possible for me to squeeze a copy of Processor Technology's 5K BASIC into six 2708-type programmable read-only memories. A monitor (which resides in another 2708) contains routines to load memory, display memory, jump to a specified address, and begin program execution. The monitor can also fill blocks of memory, move blocks of memory, set the real-time clock, read the real-time clock, print the current time on the terminal, record programs on cassette, and play back programs from cassette.

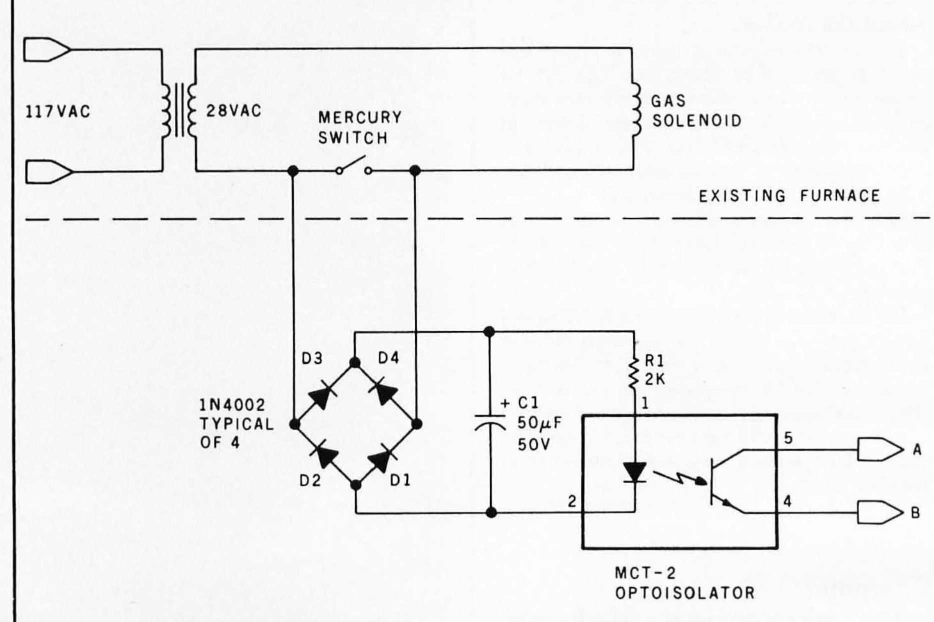


Figure 1: *Electronic circuit that allows the computer to tell whether the furnace burner is on or off. The mercury switch is contained in the thermostat, and is connected in series with the gas solenoid and a source of 28 VAC electricity. The voltage difference between the contacts of the mercury switch is 28 VAC when the switch is open (when the furnace burner is off), and 0 VAC when the switch is closed (when the burner is on). When the furnace is off, the phototransistor in the optoisolator conducts in its saturated mode. When the furnace is on, the phototransistor does not conduct.*

The only additional necessary hardware was a simple interface to the furnace that the computer could read to determine whether the burner was on or off.

Monitoring Hardware

The only information from the furnace needed by the computer is whether the burner is on or off. This could be supplied to the processor through 1 bit of a parallel input port. Since the computer has a real-time clock, it can then calculate the length of time the burner is on and the amount of gas used. I timed the gas meter over several long periods and found that the furnace took seventeen seconds to burn a cubic foot (28.32 liters) of gas. This measurement was confirmed by figures supplied by the manufacturer of the furnace.

Figure 1 shows how I obtained the one logical bit of information (on or off) from the furnace circuitry. The gas solenoid is connected to a 28 V AC source by the mercury switch in the thermostat. The bimetallic coil in the thermostat tips the switch on as the room temperature decreases, and tips it off as the temperature increases. The contacts of the mercury switch show 28 VAC when open (furnace burner off) and 0 VAC when closed (burner on).

When the burner is off, the 28 V AC signal is passed to a bridge rectifier made of diodes D1 thru D4. The pulsed DC current is smoothed by capacitor C1 and flows through the light emitting diode (LED) in the optoisolator (OPTO-1), saturating the phototransistor. When the mercury switch closes, no current flows through the LED, and the phototransistor will be in the nonconducting state.

If you have a parallel input port available (actually only one bit of an 8-bit port is needed), you need only connect point A of the circuit to the input of the least-significant bit (LSB) of the port and point B to the system ground. A 1000 ohm pull-up resistor to the +5 V supply should also be connected to the input. A twisted pair of wires can be used to connect the circuitry in the furnace with the input port on the computer.

My computer did not originally have a parallel input port, so I had to construct a simple one with a minimum of parts. Referring to figure 2, an 8T95 three-state buffer was

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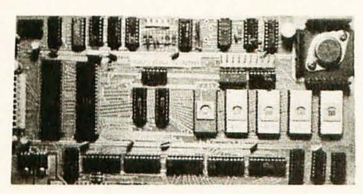
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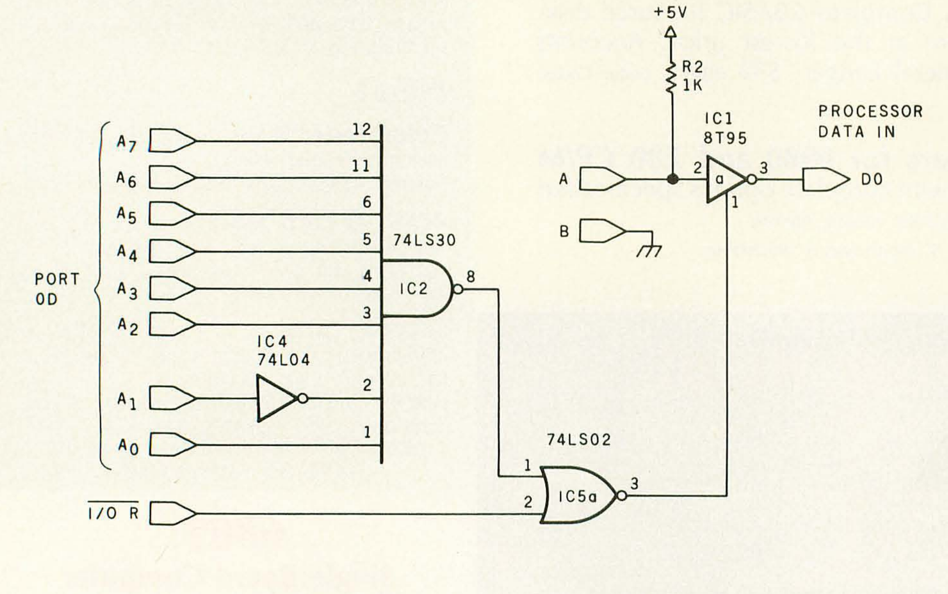
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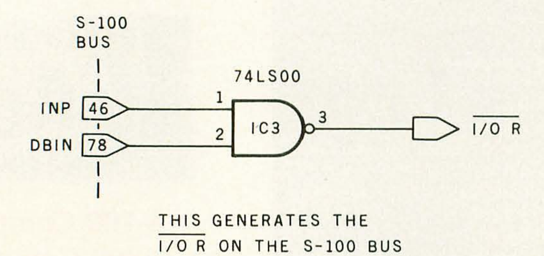
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Figure 2: *A simple input port that can be used to transfer one bit of information concerning the furnace status to the computer. The address of this input port is hexadecimal 0D, determined by the eight-input NAND gate and the inverter.*

Number	Type	+5 V	GND
IC1	8T95	16	8
IC2	74LS30	14	7
IC3	74LS00	14	7
IC4	74L04	14	7
IC5	74LS02	14	7





Listing 1: *The "watchdog" program, written in Processor Technology 5K BASIC. Once started, this program loops continuously, monitoring the status of the furnace and printing summary data as required. A flowchart is shown in figure 3.*

```
10 REM = FURNACE WATCHDOG
12 REM - TO BE STARTED WITH FURNACE OFF
20 DIM M2(12)
22 I9=0;J9=0;G2=.21149
26 PRINT"INPUT MONTH,DAY"
28 INPUT M9,D9
30 PRINT"LAST DOLLAR TOTAL"
35 INPUT K
40 PRINT;PRINT
41 REM - GET TIME
42 GOSUB 600
43 S2=S
44 REM - STORE # DAYS IN MONTHS
45 FOR C=1 TO 12
46 READ M2(C)
48 DATA 31,28,31,30,31,30,31,31,30,31,30,31
49 NEXT C
50 L=0
55 REM - LOOP TO READ INPUT PORT 14
60 T=0
70 FOR C=1 TO 10
80 Z=CALL(12074)
```

Listing 1 continued on page 80

used, as the data bus in the computer is bidirectional. A 74LS30 8-input NAND gate and a single inverter decode the input port address, which is 0D hexadecimal or thirteen decimal. The $\overline{\text{I/O R}}$ signal from the Intel 8228 bus driver gates the input signal onto the bus. This $\overline{\text{I/O R}}$ signal can be duplicated in an S-100 bus machine by NANDing the input instruction (INP) signal from pin 46 together with the DBIN signal on pin 78.

Real-Time Clock

Before I begin to describe the software used, a few words about the real-time clock will be useful. The real-time clock that is used is my own design, and is unique to this computer. Any type of real-time clock could be used in the system. It makes no difference whether or not it uses extensive hardware, software timing loops, interrupts, etc— as long as the processor can obtain the time upon request and be able to convert this into the time of day in absolute daily elapsed seconds (ie: time of day 00:00:00 equals 0 seconds, time 02:03:04 equals $2 \times 3600 + 3 \times 60 + 4 = 7384$ seconds and time 23:59:59 equals 86,399 seconds). A subroutine is used in the BASIC program (in listing 1) beginning at line 600 to derive the absolute time in seconds from the twenty-four-hour real-time clock. Regardless of the type of real-time clock you use, some sort of subroutine will be necessary to calculate the time in absolute seconds. It is also very convenient to have a routine that prints out the current time in traditional form on your terminal.

Software

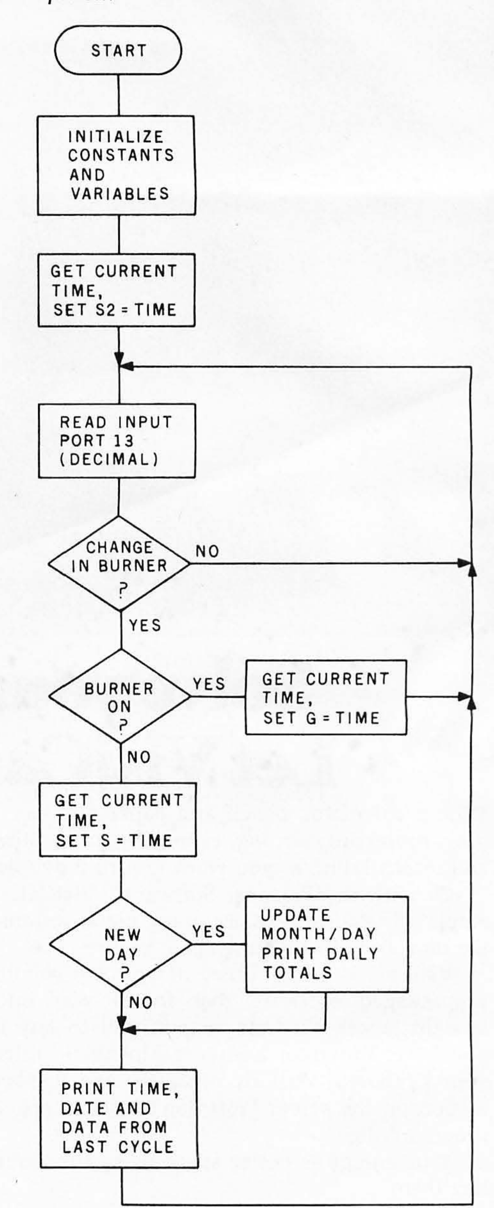
The main program used by this system (listing 1) is written in BASIC. The BASIC interpreter used is Processor Technology's 5K BASIC. Simply stated, the program continually monitors the furnace burner's state, and each time it shuts off, the computer prints out a line of information on the furnace's last burn cycle. A *burn cycle* is defined as the interval between two burner-off events.

To eliminate errors induced by switch bounce, ten read operations are done in sequence from the input port. If all of the ten inputs represent the same on or off state, then the pro-

Listing 1 continued:

```
90 T=T+Z
100 NEXT C
110 IF T=L THEN 60
120 IF T=10 THEN 160
130 IF T=0 THEN 210
140 GOTO 60
150 REM - GAS ON ROUTINE
160 GOSUB 600
170 G=S
180 L=10
190 GOTO 60
200 REM - GAS OFF ROUTINE
202 REM - DO CALCULATIONS AND PRINT OUT LAST BURN CYCLE
210 GOSUB 600
215 REM - HAS TIME CROSSED MIDNIGHT
220 IF G<S THEN 250
230 I=86400-G+S
240 GOTO 260
250 I=S-G
260 J=(I/1700)*G2
262 I9=I9+I
264 J9=J9+J
265 K=K+J
266 REM - HAS TIME CROSSED MIDNIGHT
268 IF S2<S THEN 274
270 D=86400-S2+S
272 GOSUB 500
273 GOTO 275
274 D=S-S2
275 R=(I/D)*100
280 Q=CALL(6262)
288 PRINT TAB(1),M9,"/",D9,
290 PRINT TAB(11),"On",INT((I/60)*100)/100,"Min.,",
292 PRINT TAB(27),INT(R*10)/10,"% of",INT((D/60)*100)/100,
294 PRINT TAB(43),"Min. cycle    $",INT((J+.005)*100)/100,
296 PRINT TAB(65),"$",INT((K+.005)*100)/100
298 S2=S
300 GOTO 50
499 REM - MON/DAY UPDATE
500 D9=D9+1
510 IF D9<=M2(M9) THEN 560
520 D9=1
530 M9=M9+1
540 IF M9<13 THEN 560
550 M9=1
560 PRINT;PRINT;PRINT
565 PRINT"DAILY TOTALS -- On",INT((I9/864)*10)/10,"%"
568 I8=I9/1700
570 PRINT TAB(16),"Cost is $",INT((I8*G2)*100)/100
575 PRINT TAB(16),INT(I8*10)/10,"CCF Used"
580 PRINT;PRINT;PRINT
585 I9=0;J9=0
590 RETURN
599 REM - FETCH TIME IN SEC.
600 D1=CALL(12032)
610 D2=CALL(12041)
620 D3=CALL(12047)
630 D4=CALL(12053)
640 D5=CALL(12059)
650 D6=CALL(12065)
660 M=(10*D1+D2)*60+(10*D3+D4)
670 S=M*60+(10*D5+D6)
680 RETURN
```

Figure 3: *Simplified flowchart of the watchdog program given in listing 1. Once started, the program loops continuously, checking the status of the furnace and printing summary data as required.*



gram accepts this as a true indication of the burner's status. Figure 3 is a simplified flowchart of the program.

Essentially the program loops continually, looking for a change in the burner status. If there is a change, there are two different flow paths depending on whether the burner has just turned on or turned off. If the burner has just turned on, the current time is stored in the variable G. If it has just shut off, the current time and the value stored in G are used to calculate how long the burner was on and the percentage of time the burner

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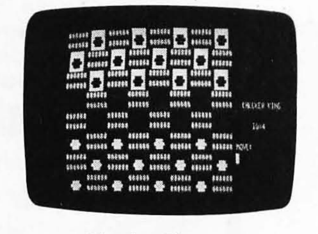
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Table 1: *Use of variables in the BASIC program of listing 1. The physical items of data represented by each variable are shown here. During leap years (such as 1980), the array M2 must be modified to reflect the greater number of days in the month of February.*

D	Number of total seconds in the previous burner cycle, from last burner-off event to current burner-off event.
D1	Most significant digit (MSD) of current time; number of tens of hours.
D2	One digit of current time; number of units of hours.
D3	One digit of current time; number of tens of minutes.
D4	One digit of current time; number of units of minutes.
D5	One digit of current time; number of tens of seconds.
D6	Least significant digit (LSD) of current time; number of units of seconds.
D9	The current day of the month.
G	Absolute daily elapsed time in seconds that the burner was on in the current cycle.
G2	Cost of gas in dollars for 100 cubic feet (2832 liters).
I	Number of seconds the burner was on in the previous cycle.
I8	Total number of units of gas used for the day, one unit = 100 cubic feet (2832 liters).
I9	Accumulated number of seconds the burner has been on during the day.
J	Cost, in dollars, for the previous burner cycle.
J9	Accumulated cost of gas for the total day.
K	Accumulated total cost of gas since the program was started.
L	Set to zero if the burner is currently off, set to ten if the burner is currently on.
M	Current time in minutes from 00:00:00.
M2	A subscripted array of twelve values containing the number of days in each month, ignoring leap years.
M9	The current month.
R	Percentage of time the burner was on during the previous burner cycle.
S	Absolute daily elapsed time in seconds from 00:00:00.
S2	Time, in absolute daily elapsed seconds, that the burner was off in the previous cycle.
Z	The value returned by a machine language subroutine, set to zero if the burner is off and to one if on.

was on during the last cycle. A calculation of the cost of the gas used is done, as well as the total running cost. This information is then printed out on the terminal.

Table 1 describes the physical data that the variables in the program represent. These descriptions should help in understanding the program's details.

There are eight places where the CALL function is used in the BASIC program. The CALL function branches to a machine language subroutine in the following way. An address (in decimal) is supplied as the argument, and program execution is transferred to that address. Any desired value to be returned to the BASIC program is put in the variable to the left of the equal sign by placing it in the HL register pair before returning from the subroutine. A RETURN instruction at the end of the machine language routine returns control back to the BASIC program. My machine language routines begin at hexadecimal address 2F00.

The CALL at line 80 simply reads input port hexadecimal 0D and returns either a logical zero or one to denote whether the burner is off or on, respectively.

The CALL at line 280 transfers control to a machine language routine that reads the real-time clock and prints the current time on the terminal in standard form. The variable Q is not used for any calculations, but rather just supplies the necessary syntax for the BASIC interpreter. A subroutine called TTOP, which resides at hexadecimal address 189D in the monitor, is used within this routine as well as in the machine language routines that begin at hexadecimal memory location 2F00. TTOP reads the real-time clock and stores the 6-digit time (as ASCII characters) beginning at hexadecimal memory location 2254.

The six CALLs beginning at line 600 are used to retrieve the individual digits of the current time of day from the real-time clock. The six digits are then used to calculate the absolute time of day in seconds.

The machine language subroutines are shown in listing 2 and are quite straightforward. The subroutines S1 through S6 each read a single digit of the time and return it to the BASIC program in the HL register pair. Subroutine S1 is always the first called, and the actual clock-read operation is done here just once. MASK is used to strip high-order bits from the ASCII character representation of

Listing 2: *Machine language subroutines that are called by the BASIC program of listing 1, shown here in assembler for the 8080 processor. Routines S1 through S6 each read a single digit of the time from the real-time clock. The digit value is returned to the BASIC program in the HL register pair. S1 is always the first to be called, and the actual clock read operation is done only once. MASK strips the high-order bits from the ASCII character representation of the digit.*

```
8080 MACRO ASSEMBLER, VER 2.0  ERRORS = 0 PAGE 1

                        ; FURNACE WATCHDOG
                        ; WRITTEN BY T. WIERENGA, FEB. 1978
                        ;
                        ; READ HOURS,MINUTES,SECONDS
                        ;
 189D                   TTOP    EQU  189DH
 2F00                           ORG  2F00H
 2F00    CD9D18         S1:     CALL TTOP          ; READ CLOCK
 2F03    3A5422                 LDA  2254H         ; STORE IN MEMORY
 2F06    C3242F                 JMP  MASK          ; GET TENS HOURS
 2F09    3A5522         S2:     LDA  2255H         ; GET UNITS HOURS
 2F0C    C3242F                 JMP  MASK
 2F0F    3A5622         S3:     LDA  2256H         ; GET TENS MINUTES
 2F12    C3242F                 JMP  MASK
 2F15    3A5722         S4:     LDA  2257H         ; GET UNITS MINUTES
 2F18    C3242F                 JMP  MASK
 2F1B    3A5822         S5:     LDA  2258H         ; GET TENS SECONDS
 2F1E    C3242F                 JMP  MASK
 2F21    3A5922         S6:     LDA  2259H         ; GET UNITS SECONDS
 2F24    E60F           MASK:   ANI  00FH
 2F26    6F                     MOV  L,A           ; RETURN VALUE IN H,L
 2F27    2600                   MVI  H,0
 2F29    C9                     RET
                        ; READ INPUT PORT 13 (0DH)
                        ; 0=FURNACE OFF, 1=ON
                        ;
 2F2A    DB0D                   IN   13
 2F2C    E601                   ANI  1             ; LSB ONLY USED
 2F2E    6F                     MOV  L,A           ; RETURN VALUE IN H,L
 2F2F    2600                   MVI  H,0
 2F31    C9                     RET
                        END
NO PROGRAM ERRORS
1
8080 MACRO ASSEMBLER, VER 2.0  ERRORS = 0 PAGE 2

                   SYMBOL TABLE

 * 01

 A      0007     B      0000     C      0001     D      0002
 E      0003     H      0004     L      0005     M      0006
 MASK   2F24     PSW    0006     S1     2F00 *   S2     2F09 *
 S3     2F0F *   S4     2F15 *   S5     2F1B *   S6     2F21 *
 SP     0006     TTOP   189D

!C B1B0

:102F0000CD9D183A5422C3242F3A5522C3242F3A78
:102F10005622C3242F3A5722C3242F3A5822C324BF
:102F20002F3A5922E60F6F2600C9DB0DE6016F2606
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:0000000000
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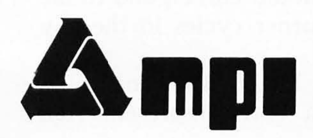
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Circle 51 on inquiry card.

Table 2: *Example of the output produced by the BASIC watchdog program of listing 1.*

```
01:50:25  2 / 22   On 9.78 Min.,    3.4 % of 285.41 Min. cycle   $ .07   $ 3.27
02:25:42  2 / 22   On 11.23 Min.,   31.7 % of 35.43 Min. cycle   $ .08   $ 3.36
03:00:45  2 / 22   On 11.31 Min.,   32.2 % of 35.06 Min. cycle   $ .08   $ 3.44
03:34:40  2 / 22   On 11.51 Min.,   33.9 % of 33.91 Min. cycle   $ .09   $ 3.53
04:08:46  2 / 22   On 11.45 Min.,   33.5 % of 34.1 Min. cycle   $ .09   $ 3.61
04:43:22  2 / 22   On 11.65 Min.,   33.6 % of 34.58 Min. cycle   $ .09   $ 3.7
05:18:22  2 / 22   On 11.5 Min.,    32.8 % of 35.01 Min. cycle   $ .09   $ 3.79
05:53:31  2 / 22   On 12.33 Min.,   35.1 % of 35.13 Min. cycle   $ .09   $ 3.88
07:23:36  2 / 22   On 65.9 Min.,    73.1 % of 90.08 Min. cycle   $ .49   $ 4.37
09:56:08  2 / 22   On 10.1 Min.,    6.6 % of 152.53 Min. cycle   $ .08   $ 4.45
10:35:23  2 / 22   On 11.88 Min.,   30.2 % of 39.26 Min. cycle   $ .09   $ 4.54
11:16:10  2 / 22   On 11.26 Min.,   27.6 % of 40.78 Min. cycle   $ .08   $ 4.62
12:00:01  2 / 22   On 10.88 Min.,   24.8 % of 43.83 Min. cycle   $ .08   $ 4.7
12:44:40  2 / 22   On 10.5 Min.,    23.5 % of 44.66 Min. cycle   $ .08   $ 4.78
13:33:57  2 / 22   On 10.03 Min.,   20.3 % of 49.28 Min. cycle   $ .07   $ 4.85
14:25:37  2 / 22   On 9.7 Min.,     18.7 % of 51.66 Min. cycle   $ .07   $ 4.93
15:27:48  2 / 22   On 9.28 Min.,    14.9 % of 62.16 Min. cycle   $ .07   $ 5
16:32:27  2 / 22   On 9.21 Min.,    14.2 % of 64.66 Min. cycle   $ .07   $ 5.06
17:27:30  2 / 22   On 10.53 Min.,   19.1 % of 55.03 Min. cycle   $ .08   $ 5.14
18:17:55  2 / 22   On 11.48 Min.,   22.7 % of 50.43 Min. cycle   $ .09   $ 5.23
20:43:56  2 / 22   On 117.3 Min.,   80.3 % of 146.01 Min. cycle   $ .88   $ 6.1
21:19:56  2 / 22   On 14.43 Min.,   40 % of 36      Min. cycle   $ .11   $ 6.21

DAILY TOTALS -- On 28 %
                 Cost is $ 3
                  14.2 CCF Used
```

each number to yield the binary value before it is returned to the BASIC program.

The input subroutine begins at hexadecimal memory address 2F2A. Only the least significant bit (LSB) of the byte input from input port 0D is used.

Some sample output from the mainline program is shown in table 2. Although a large amount of data is supplied by this program, it is difficult to visualize the trends in the daily consumption of gas without some additional analysis of the data. Therefore, a second BASIC program is used to produce a simple bar chart of daily gas consumption.

The bar chart program appears as listing 3. Several sets of data, each consisting of three numeric values, are obtained from the "watchdog" program of listing 1. These data sets are entered into the DATA statements beginning at line 500. Each set is read as the variables H, M, and T, which are the hour and minute the burner shut off after each cycle, and the length of time it was on. The number of data sets should correspond to the number of burner cycles in the day being charted.

An array D of 144 entries is created. Each entry represents ten

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Listing 3: *BASIC program that prints bar graphs from data accumulated by the watchdog program of listing 1. An example of the output of this program is shown in figure 4.*

```
100 REM - BAR CHART PRINTOUT FOR
110 REM - FURNACE WATCH DOG
120 REM
130 DIM D(144)
135 REM - SET ARRAY TO ZERO
140 FOR I=1 TO 144
150 D(I)=0
160 NEXT I
165 REM - READ TIMES
170 READ H,M,T
175 IF T=0 THEN 250
177 REM - CALCULATE PLACE IN ARRAY
178 REM - AND LENGTH OF TIME ON
180 X=H*6+INT((M/10)+.5)
190 T=INT((T/10)+.5)
200 IF T>0 THEN 220
210 T=1
212 REM - FILL ARRAY WHEN ON
220 FOR I=X TO X-T+1 STEP -1
230 D(I)=1
240 NEXT I
245 GOTO 170
250 RESTORE
252 GOSUB 400
254 REM - PRINT OUT ARRAY AS 144 BARS
255 FOR J=1 TO 144
258 REM - CR IF=0
259 REM - BAR IF=1
260 IF D(J)=0 THEN 300
270 FOR K=1 TO 30
280 PRINT"X",
290 NEXT K
291 REM - PRINT TIME ON LAST BAR
292 IF D(J+1)<>0 THEN 300
294 READ H,M,T
296 PRINT"   ",H,"HRS.",M,"MIN.",
300 PRINT
310 NEXT J
315 GOSUB 400
320 STOP
399 REM - PRINT LINE OF DASHES ROUTINE
400 FOR Z=1 TO 40
402 PRINT"-",
404 NEXT Z
406 PRINT
408 RETURN
500 DATA 1,50,9.78,2,26,11.23,3,1,11.31,3,35,11.51,4,9,11.45
510 DATA 4,43,11.65,5,18,11.5,5,53,12.33,7,24,65.9,9,56,10.1
520 DATA 10,35,11.88,11,16,11.26,12,0,10.88,12,45,10.5,13,34,10.03
530 DATA 14,26,9.7,15,28,9.28,16,32,9.21,17,28,10.53,18,18,11.48
540 DATA 20,44,111.3,21,20,14.43
999 DATA 0,0,0
```

minutes of time during the day. A value of one is assigned to an array entry if the furnace was on during the major part of the corresponding ten minute interval, otherwise the value is left at zero. This array is then printed as 144 lines, which are blank if the array value is equal to zero and filled in with Xs if the value is equal to one. The time is printed alongside the filled-in bar corresponding to the time interval in which the burner shut off. A sample output of the program is shown in figure 4.

The particular day shown in figure 4 is February 22 1978. Several interesting features can be determined from the output. The thermostat was turned down sharply before midnight, and the furnace did not come on again until 1:50 AM. The furnace cycled smoothly about every half hour until 5:53 AM. At about 6:30 AM when we arose for the morning, the thermostat was turned up. The burner was on for about one hour. The heat accumulated during this hour was not completely wasted when we left for work at about 7:30 AM, and the thermostat was again turned down. Notice that the burner did not cycle again for about 2½ hours. Between 9:56 AM and 6:18 PM (18:18 in 24-hour style), the cycle time lengthened as the outdoor temperature rose, and less energy was needed to maintain a constant temperature. At about 7:00 PM (19:00) we returned home and turned the thermostat up. The furnace ran for about one hour and fifty minutes. After this time it cycled once more before the thermostat was turned down for the evening. The furnace did not cycle again until after midnight.

The burner was on twenty-eight percent of the time during this particular day, and 40,210 liters (1420 cubic feet) of gas was burned at a cost of $3. The weather was quite harsh. A low temperature of −18° C (0° F) and a high of −3° C (29° F) were recorded, and the winds were sixteen to twenty-five km per hour (ten to fifteen miles per hour).

A secondary fact that came out of the data concerns the use of a fireplace in our home. This fireplace is located in the living room, about six meters (twenty feet) around a corner from the thermostat. Whenever the fireplace is burning, even moderately, the living room area and nearby thermostat are kept warm enough that the furnace does not run at all. This encourages a considerable savings, since we use the fireplace often on evenings that we are home.

Conclusion

This system provides an excellent starting point for an individual interested in monitoring the consumption of energy used for heating. An extension of this system might be useful to a homeowner who adds a supplemental solar heating system to the conventional heating system already present in the home. Aside from monitoring the energy used, the computer in this situation could also monitor the solar energy generated. In addition, the computer could also operate the two heating systems, turning on the conventional furnace when there is not enough available solar energy.

Individuals may desire different specific information from the furnace watchdog, therefore they may have to write their own software for a systematic analysis of the data obtained. ■

Figure 4: *Sample output of the bar chart program of listing 3. This provides a graphic record of data obtained from the watchdog program of listing 1.*

```
--------------------------------


XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   1 HRS. 50 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   2 HRS. 26 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   3 HRS. 1 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   3 HRS. 35 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   4 HRS. 9 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   4 HRS. 43 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   5 HRS. 18 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   5 HRS. 53 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   7 HRS. 24 MIN.


XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   9 HRS. 56 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   10 HRS. 35 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   11 HRS. 16 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   12 HRS.0 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   12 HRS. 45 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   13 HRS. 34 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   14 HRS. 26 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   15 HRS. 28 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   16 HRS. 32 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   17 HRS. 28 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   18 HRS. 18 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
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XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   20 HRS. 44 MIN.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX   21 HRS. 20 MIN.



--------------------------------
```

HOW BOB SCHMIDT AND HIS MICROSOFT BASIC COMPILER TURNED AN ORDINARY COMPUTER INTO A GENIUS.

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Bob says, "When Microsoft comes out with a new product, I know it's got to be good. And this BASIC Compiler is the wizard I've been waiting for.

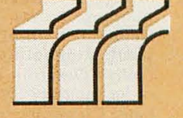
"At last, I can generate relocatable machine language modules from my Microsoft BASIC programs—machine code that's highly optimized. And because the Microsoft macro assembler and loader come with the BASIC Compiler, BASIC programs are easily linked to assembly language subroutines or Microsoft FORTRAN and COBOL programs. Just like the pros," smiled Bob.

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Editorial *continued from page 10:*

what are the typical criteria expected in the modern personal computer? For one thing, systems software is required to use the rich hardware capabilities of the small system. The days of an integer subset of high-level language X with a disk operating system capable of only simple data transfer operations are gone. The modern personal computer user at a minimum requires an extended disk BASIC with files and strings and an operating system with all the appropriate filing, editing and utility amenities. Nearly all the widely advertised systems have this kind of capability.

In what I consider to be the ultimate in usefulness for current computers, we find the high-level language orientation of computers with *manufacturer-independent* Pascal, C, ANSI standard FORTRAN, and BASIC languages.

The particular case of the UCSD Pascal system is pioneering a machine independence never before seen in computing. Users are driving the mass-produced computer market, with no single company having dominance enough to dictate styles of languages. The success of UCSD Pascal over the past two years as a machine-independent package available from numerous manufacturers is one of the joys of present-day computing. I can edit, compile, and use the operating system on one machine in a manner identical with my interactions on another machine. I use three different computers with totally different hardware processor designs — yet, with UCSD Pascal, the operating systems are functionally identical, so I do not have to switch personalities constantly.

I have demonstrated with friends that it is possible to send object code produced by the UCSD Pascal compiler to other machines where it will execute and behave the same way. The manner of transportation at the hardware level is sometimes via disk media where compatibility exists, and, where different disk formats are involved, we have transferred files through the means of serial RS-232C compatible data connections.

This Pascal-based system is actively supported by a number of manufacturers, now prominently including personal computer manufacturers Apple and North Star as well as the integrated circuit manufacturer Western Digital. UCSD Pascal is available in versions for DEC PDP-11 minicomputer systems (upon which it was originally developed), CP/M-based 8080 and Z80 systems, Motorola 6800-based systems, and even the Radio Shack TRS-80. On all these diverse hardware configurations — with a working useful criterion of 500 K bytes mass storage, 50 K or more bytes of memory — the same operating system and compilers run, can pass files compatibly between each other, and achieve systems performance sometimes missing from the minicomputers and behemoth computers of today and yesterday.

So with this in mind as the ultimate in off-the-shelf technology, let's summarize: A desirable contemporary personal computer has 64 K bytes of memory, about 500 K bytes of mass storage on line, any old competently designed computer architecture, upper and lowercase video terminal, printer, and high-level languages such as that provided by the UCSD Pascal software system. This is the state of the art in small computing as it stands to date.

A Particular System

The previous discussion of the glowing generalities of our entry into the 1980s with personal computing technologies is only part of the information you need when contemplating a purchase. To provide a concrete example of a particular case, I shall describe the new computer I just bought. First, why did I need a new one? The computer I have been using until recently (a Northwest Microcomputer Systems Model 85/P) executes the UCSD Pascal system, meets all the minimum requirements, and had served me well for nearly a year.

But no computer, however competently engineered, is immune to dumb users like yours truly. As an attempt to get around a relatively minor hardware problem, I managed to plug a terminal into the wrong socket and fry a power supply, possibly worse. After a month of withdrawal symptoms, my frustration level reached such a peak that I had to get another computer. . . . NOW! . . . INSTANTLY! Thus the genesis of this month's editorial celebrating the existence of off-the-shelf personal computers — when I had the need to get one, a computer was available from a local retailer, and purchased with cash over the counter.

To be sure, I had been contemplating a new computer for some time. I had also been looking into a possible small UCSD Pascal facility for a good friend of mine who desires a computer to handle his local political campaign data processing activities. Thus I had actually priced out a system that was available off the shelf at Bob McGuffie's Computerland store in Nashua, New Hampshire. The system was an Apple II with UCSD Pascal and assorted peripherals. Then, the frustration level rose to exceed my threshold of action during the weekend of the Philadelphia Personal Computing '79 show. On Saturday of that week, I called Bob at his store in New Hampshire to firm up an order for a slightly expanded system.

The order for the system was placed on October 6. I picked up the system on October 11, with all items except an extra set of read-only memories for a second pair of floppy disk drives. Here is what I am now using to write editorials, write various memos involved with my everyday work, explore miscellaneous uses of personal computing, etc:

Apple II Plus Computer with . . .
- UCSD Pascal Option (64 K total memory),
- Serial Communications Interface,
- Four 5-inch floppy disk drives (2 controllers, 520 K bytes on line),
- Parallel Printer Interface,
- D C Hayes Micromodem II, and extra phone line.

To this list of equipment should be added an Integral Data Systems Model 440 "Paper Tiger" printer which I had ordered a month earlier with the intention of using as a scratch printer. Also added to this list is a COPS-10 terminal which was manufactured by the Computer Peripheral Corp, of which several were already owned by BYTE. This set of equipment (including the printer but omitting the cost of the COPS-10 terminal) cost only $6000 and, except for two read-only memory parts which arrived ten days later, was delivered off the shelf.

As the Apple Pascal comes delivered, it is oriented

toward use of the Apple II video display, a 24-line by 40-character display built into the computer. Because of the short line width and uppercase only characteristics of the built-in Apple II display, I do not prefer to use it as a primary UCSD Pascal terminal. This is no great problem because the clever hardware design of the Apple Pascal option and the documentation which comes with the system make it fairly trivial to reconfigure the UCSD Pascal system for operation via any typical terminal. At bootstrap time, the Apple II Pascal system simply checks to see if a Serial Comunications card is plugged into slot number 3 of the Apple peripheral bus. If so, it uses that card as the system terminal instead of the built-in Apple display. It of course makes default assumptions about the terminal, but these proved to be adequate to check some major points about the interface. The major technical problem was discovering that my terminal generated a default bit in the wrong state when parity was suppressed, and that its cursor addressing feature did not seem to work. The parity default problem was solved by changing a jumper option in the terminal. The cursor addressing problem was solved by a GOTOXY kludge.

Using the Apple II built-in display as a bootstrapping tool, I was able to run the UCSD system's SETUP program to create a SYSTEM.MISCINFO file for the COPS-10 terminal. This mode of operation also enabled me to write a custom Pascal "GOTOXY" procedure which is used by the UCSD Pascal system to do cursor addressing with the particular terminal involved. It turned out that, as a kludge, I had to do cursor addressing with a "home" followed by a sequence of "cursor down" and "cursor right" operations — a technical point I have not yet resolved. The problem that keeps me from using direct cursor addressing is either the inability of the terminal to understand its documented addressing sequences, or the inability of the compiled GOTOXY procedure to emit the cursor escape character. The kludge gets around the problem temporarily at the price of some cursor movement delays. Listing 1 shows the Pascal code which resulted. Since the program was edited and compiled before I had the terminal attached, it uses uppercase only. As I write these notes the cursor addressing kludge remains in the system, slowing down operation of the UCSD system's screen editor during deletions and cursor positioning.

After getting the terminal to work with default parameters I was able to write a Pascal procedure which is compiled and saved as SYSTEM.STARTUP. When

Listing 1: *This GOTOXY procedure meets the requirements of cursor control for the UCSD Pascal system, given an Apple II driving a COPS-10 terminal. It uses an inelegant kludge for cursor positioning, one which requires a total of 105 character times to reach the worst case position. Sooner or later it will be replaced when direct cursor control's subtleties are mastered using my terminal. This listing (and listing 2) was produced on the Integral Data Systems Model 440 "Paper Tiger" printer that is attached to the Apple via a parallel printer port. A custom Pascal print utility program is used to transfer files to the printer in formatted form instead of using the system's Filer program.*

```
PROGRAM GOXY;

PROCEDURE FGOTOXY( X,Y:INTEGER );

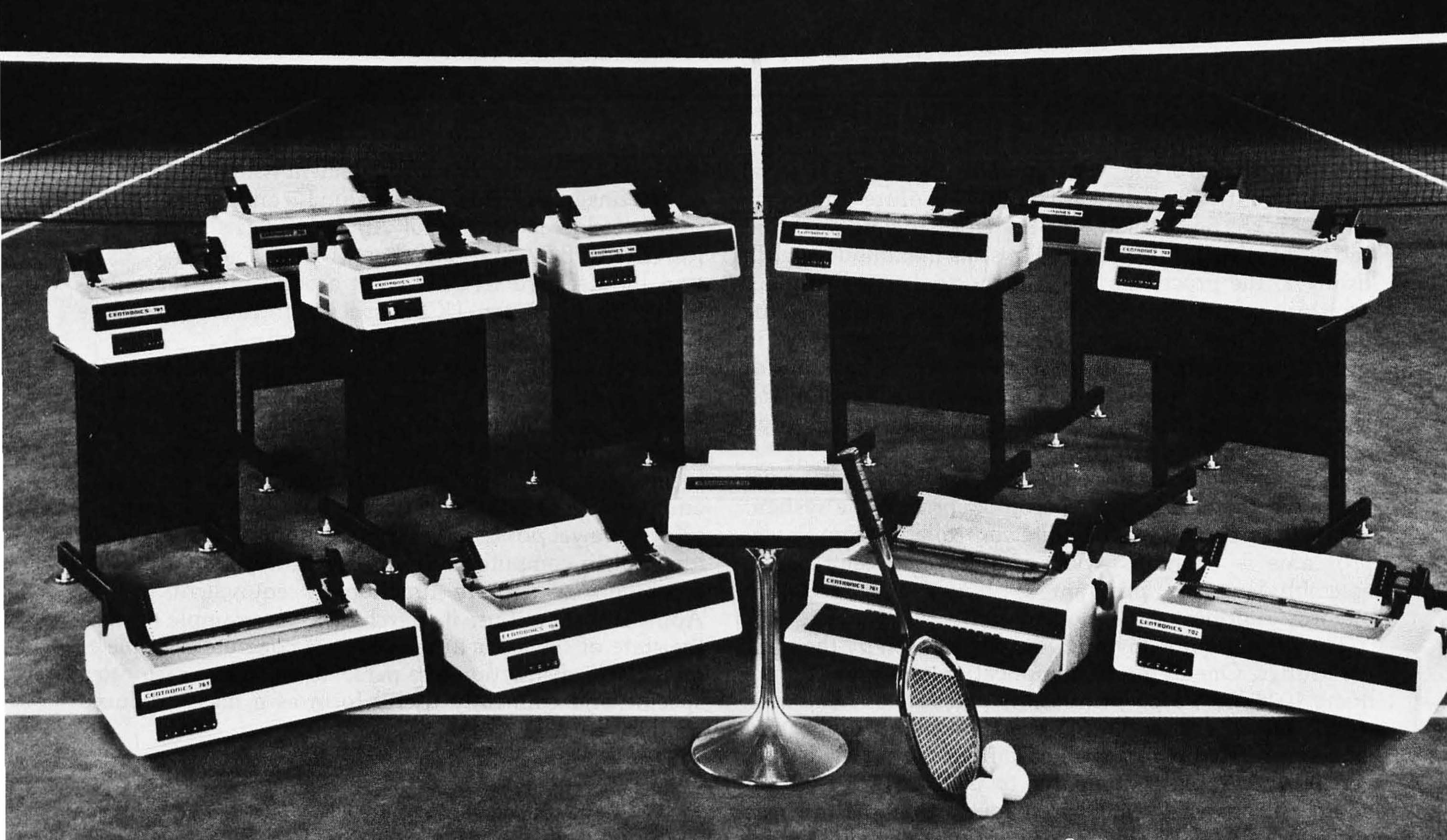
(* COPS 10 - GOTOXY *)

CONST
 HOME = 25;
 DOWN = 10;
 ACROSS = 12;

VAR
 SEND: PACKED ARRAY[0..0] OF 0..255;
 J,I : INTEGER;

BEGIN
   SEND[0] := HOME;
   UNITWRITE( 2,SEND,1 );
   IF X>79 THEN X:=79
   ELSE IF X<0 THEN X:=0;
   IF Y>23 THEN Y:=23
   ELSE IF Y<0 THEN Y:=0;
   IF Y<>0 THEN
    BEGIN
     SEND[0] := DOWN;
     FOR I := 0 TO Y-1 DO
      UNITWRITE( 2,SEND,1 )
    END;
   IF X<>0 THEN
    BEGIN
     SEND[0] := ACROSS;
     FOR I := 0 TO X-1 DO
      UNITWRITE( 2,SEND,1 )
    END
 END;


BEGIN (* DUMMY MAIN *)
END.
```



Listing 2: *This is a first cut at the program SYSTEM.STARTUP, which is executed every time UCSD Pascal wakes up on the Apple II with the COPS-10 terminal. It uses direct addressing of memory through a standard Pascal variant record technique isolated in the procedure "set_memory." The memory locations directly addressed from procedure "set_up_cops" are the addresses described for various parameters of the Apple II Serial Communications Interface card.*

```
PROCEDURE set_up_cops;
   CONST
      slot=3;
      data_rate_address=1144;
      stop_bits_address=1272;
      parity_address=1400;
      linewidth_address=1784;
      data_bits_address=1912;
      op_modes_address=2040;


   PROCEDURE set_memory (value,address:INTEGER);

      TYPE
         ptr = ↑CHAR;
         memory_access=(pointer,number);
         memory =
            RECORD
               CASE memory_access OF
                  pointer : (a_pointer:ptr);
                  number  : (a_number:INTEGER)
            END;
      VAR
         anybyte : memory;

      BEGIN {set_memory}
         anybyte.a_number := address+slot;
         anybyte.a_pointer↑ := CHR(value)
      END;


   BEGIN {set_up_cops}

   {
      All constants for setting up the Apple-II serial
   terminal port are determined from information on
   pages 21 to 24 of the Serial Interface Card manual,
   #WP-A2L0008/030-0012 ... 3/79-10K RP.  Reference is
   also made to the manual for the COPS-10 terminal
   }

   { 19200 BPS = 1 }
   set_memory(1,data_rate_address);

   { COPS can use 2 stop bits }
   set_memory(3,stop_bits_address);

   { no parity, no checksum }
   set_memory(6,parity_address);

   { COPS has 80 character lines }
   set_memory(80,linewidth_address);

   { COPS generates 8 data + 1 start bits }
   set_memory(9,data_bits_address);


   { no linefeed,lower case,no delay,no television }
   {       0     +    32    +   64   +      128      }
   set_memory(224,op_modes_address)

   END {set_up_cops};


BEGIN
   set_up_cops;
   WRITELN('');
   WRITELN('');
   WRITELN('');
   WRITELN('COPS-10 terminal setup completed');
   WRITELN('');
   WRITELN('');
   WRITELN('');
   WRITELN('');
   WRITELN('APPLE-2 Pascal System at BYTE');
   WRITELN('');
   WRITELN('');
   WRITELN('');
   WRITELN('Remember to set the date using the Filer');
   WRITELN('')
END.
```

executed, this procedure manipulates the Apple II serial communications port through absolute memory addresses. SYSTEM.STARTUP changes defaults so that the terminal will run at 19,200 bps, its maximum rate. In listing 2, the procedure "set_memory" is used to place arbitrary information in arbitrary memory locations; the procedure "set_up_cops" references "set_memory" in order to set up the hardware specific control locations of the serial port in slot number 3 of the Apple. Reading and learning about these system configuration details took about a weekend of work.

As my deadline for this editorial approaches, I have yet to try out the D C Hayes Micromodem with the system, although I expect it will be quite controllable from Pascal programs — perhaps with a link to a short 6502 assembly-language program if I use the read-only memory routines of the modem card.

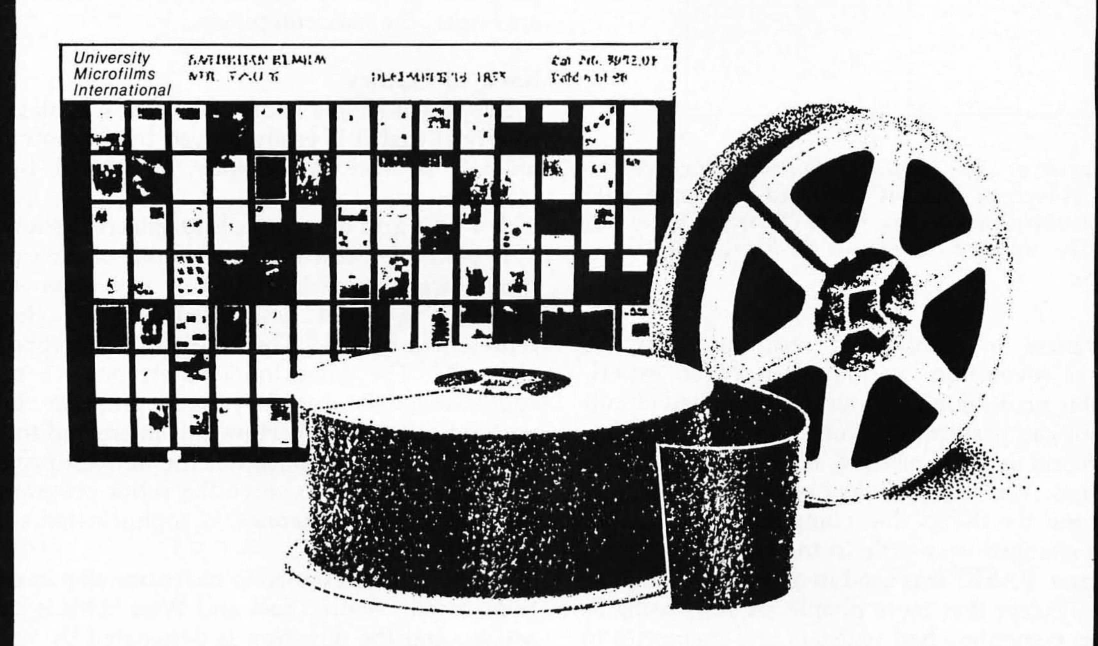
The printer quite obviously works, as seen by the sample listings. One of my first application tasks was typing in my 1025-line Pascal print utility program as I had used it on my previous UCSD-based system. Only two language related points worked differently on the UCSD version II.0 Apple as compared to the UCSD version I.5 booted through CP/M. First, I found that the intrinsic procedure PAGE(OUTPUT) did not work on my Apple, possibly due to some problem in my use of the SETUP utility to configure the system for my terminal. Second, I received a syntax error for a statement which had compiled just fine in UCSD Pascal version I.5 and which the version II.0 documentation of Apple implies should work: READ(KEYBOARD, anychar) where "anychar" is a variable declared CHAR. I got around both these problems by using the UCSD-specific intrinsic procedure UNITWRITE and UNITREAD, respectively.

This Apple II system with UCSD Pascal demonstrates that the state of the art in small computers is powerful indeed. I was able to walk into a computer store and purchase a full-fledged machine with mass storage, lots of memory, a good high-level language, operating system, and printer. At $6000 this fits the bill of being personally affordable yet possessed of those features which make for a complete computer system. Of course there are other computers which are functionally equivalent to this Apple II system. I use its purchase as an example of what the state of the art is at present — a concrete example of my "ideal" abstraction of a personal computer cast into a specific and eminently useful form as a mass-produced product.■

Note:

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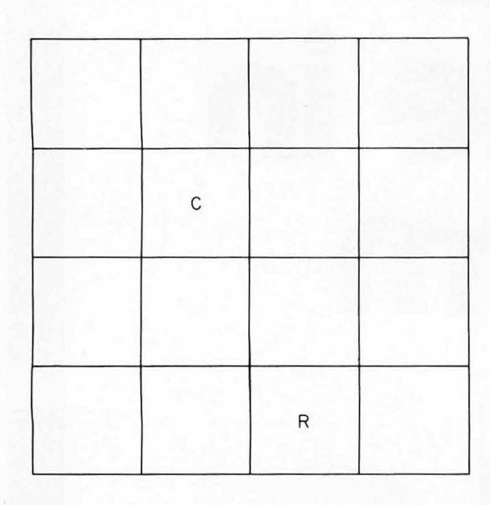


Figure 1: *The game of Look is used to illustrate the concept of computability. A piece of cheese (C) is placed in any one of the squares, and a mechanical mouse robot (R) is placed in any other square. The object of the game is for R to find C.*

Rapid advances in computing, resulting from the microcomputer revolution, are surprising even experienced computer professionals. A single integrated circuit microprocessor can perform the same number of computations per second as the expensive, large-scale computer of ten years ago. Yet, in a technical sense, both the type of computer and the things that computers are used for seem to have changed very little in the last ten years.

Ten years ago, BASIC was used in a manner similar to that of today, except that more people are now using it. Ten years ago computers had registers and memories to perform calculations; today register and memory costs have decreased fantastically. The cost of computing has declined, making it available to almost everyone. But has computing itself changed?

Can computers do any more today than they could ten years ago? Has there actually been any progress made in computing since Babbage's Analytic Engine, one hundred years ago?

What is meant by progress, and what is meant by computing? If progress is measured by the number of computers sold, the impact on society, or the size of the computer industry, then something has certainly increased and something else has decreased. What effect computers have had on our society is a moot question indeed, but one that I leave for another philosopher.

If computing is measured in terms of the number of machine cycles executed this year as compared to last year, or in terms of the number of programs written, then something has again increased and perhaps something else has decreased (like size or cost). But this kind of reasoning misses the point.

The essence of computing centers on two fundamental questions: (1) what exactly is computable, and (2) is it possible to compute more today than ten years ago? If these two questions can be answered, I believe that we can determine if progress has been made, whether this progress is due to microcomputers or their dinosaur ancestors, the maxicomputers.

Back to Games

Suppose a simple game called Look is played. Look is so trivial that it is easily played by any low intelligence animal. In fact, Look may be played by a simple machine.

A 4 by 4 grid of squares is arranged as shown in figure 1. A piece of cheese is placed in one of the squares and a mechanical mouse is placed in any other square. The mouse is a robot designated by "R"; the cheese is represented by "C." The objective is for robot R to find cheese C. The game immediately poses a problem for robot designers, for they must program R to find C without outside help. How is R instructed to locate C?

The first area of concern is the simplest program for R. If it is impossible to solve the robot programming problem in a simple manner, a sophisticated solution will probably fail.

Suppose R is designed to move one step in any of directions North, South, East and West. This is called a step action, and the direction is designated by writing STEP W for a single step in the western direction, for example.

Clearly, the robot must know when it has encountered a barrier (wall) and when it has found the cheese. Hence, mouse R is also empowered with a sensor that sets a condition code. Codes Barrier and Found are set by sensors on board R.

The STEP and condition code designs are a start toward a working mouse. They allow the robot to move

About the Author

Dr Lewis is an Associate Professor of Computer Science at Oregon State University, where he lectures on software engineering and personal computer systems. He is the author of How to Profit from Your Personal Computer *and* The Mind Appliance: Home Computer Applications.

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one square in any compass direction, detect a barrier, or locate the cheese. Surely radar or any other sophisticated tool is not needed to solve the Look problem.

Sit back and watch R move one square at a time after each command it is given. Recall, however, that Look is a game played only by a mechanical mouse without human intervention; R is a robot. A robot can be defined as follows:

Robot: Any device that operates without direct human control.

By this definition, a wall clock is a robot because it keeps time independently of direct human instruction. An automobile, however, must have direct contact with a human in order to operate.

The Look mouse must be given a brain with enough intelligence to find its own way from one square to another. This is where the concept of computing arises.

The Concept of Computing

A robot that acts without direct human guidance must possess two types of control: (1) basic actions and (2) intrinsic control for sequencing basic actions. The following two sets are chosen in keeping with the simplest possible design:

ACTIONS: STEP X, set condition code, BARRIER, FOUND, NOT FOUND, and START, STOP, where X is N, W, E, S.

CONTROL: simple sequence of a collection of actions, looping of actions, decision (branch) capability.

These actions and control are programmed into R through some yet to be determined mechanism. A pseudolanguage will be used to illustrate the programs in this article, but it is important to remember that every programming language for every computer known to the author has at least the three control constructs listed above; that is, it is conjectured that the intelligence being given R is no more than the intelligence of very simple computers. This leads to the following hypothesis:

Hypothesis 1: Any robot mouse with the actions and control given to R can be programmed to solve the Look problem.

It is possible to go even further with this hypothesis and claim that the solution to the Look problem is indeed possible. Possible means that a path from the starting location of R to the square occupied by C exists and is computable:

Hypothesis 2: Any path leading to C from R is a *computation*, and furthermore, any machine with the properties of R is able to perform such a computation.

There is now a concept of computing. For the game of Look, a computation involves finding a path. A function is a set of operations that tries to calculate a computation

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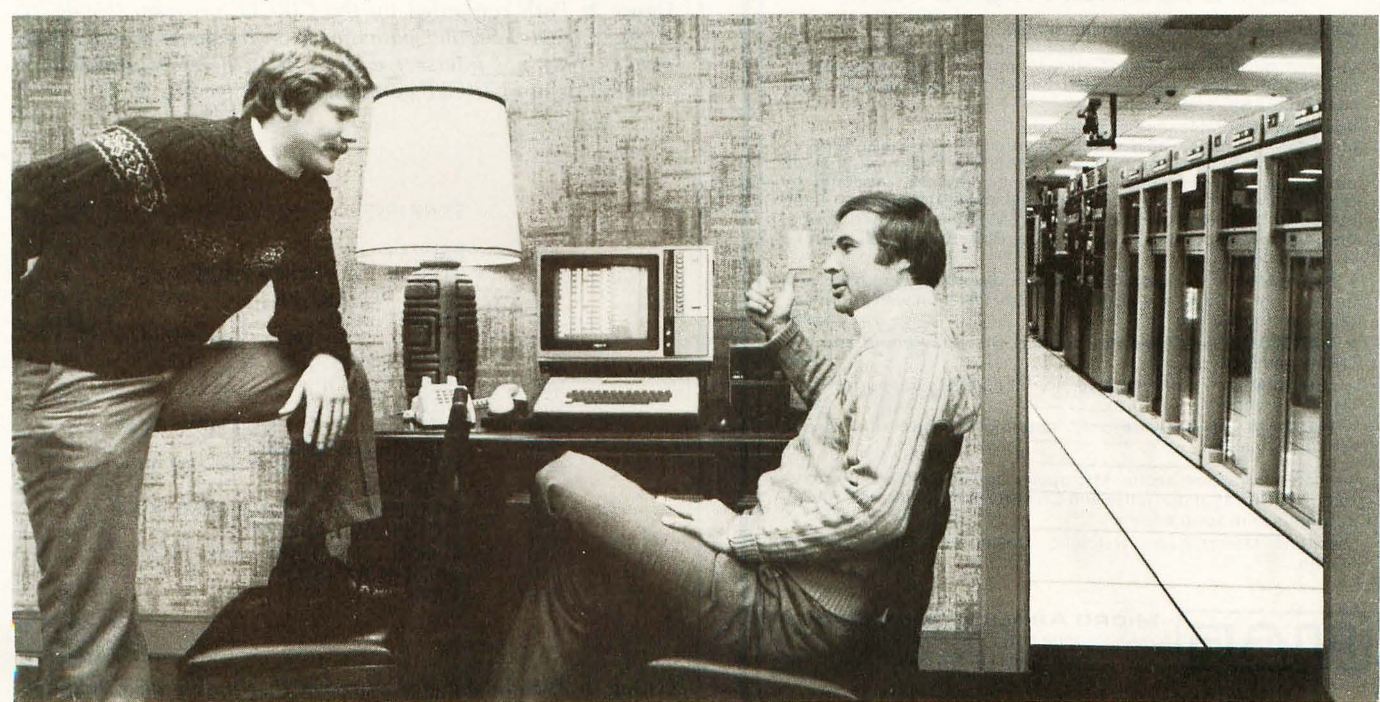
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"... but the really impressive stuff is in the back room."

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(ie: a path from R to C). A function is *computable* if R can get to C, and a function is *undecidable* if there is a possibility that R will fail to reach C.

Programming a Function in Look

Now an attempt is made to build a robot R that finds its way to C. The first attempt is again a simple approach to the problem. Suppose R is instructed to go West until reaching a barrier, then another direction is chosen and it continues to travel in that direction until reaching a barrier, and so on. Such a program might look like the pseudolanguage program shown in listing 1.

Of course, this program does not solve the Look puzzle. It may correctly locate the cheese C if C is in a boundary square (see figure 2). The problem is that C may or may not be in a square along the circular path established by program CIRCLE. Hence, it is undecidable whether or not CIRCLE computes a path leading to C.

The intelligence of R must be increased in order to guarantee a computable path (as opposed to an undecidable path). Clearly, the problem with CIRCLE is that it fails to cover every possible square. How can no square be left uncovered?

A second simple program (see listing 2) is attempted that exhaustively scans every possible square until it locates C. Lines 200 thru 220 move R to a left side square. The program must cover every square, but since R may be initially placed anywhere within Look, a starting point must be established that guarantees an exhaustive scan of the sixteen squares. This is done in lines 230 thru 250.

```
CIRCLE:
START R ;
REPEAT LOOP
STEP W ; IF FOUND THEN STOP ;
UNTIL W BARRIER ;
REPEAT LOOP
STEP N ; IF FOUND THEN STOP ;
UNTIL N BARRIER ;
REPEAT LOOP
STEP E ; IF FOUND THEN STOP ;
UNTIL E BARRIER ;
REPEAT LOOP
STEP S ; IF FOUND THEN STOP ;
UNTIL S BARRIER ;
REPEAT LOOP
STEP W ; IF FOUND THEN STOP ;
UNTIL W BARRIER ;
STOP CIRCLE
```

Listing 1: *Pseudolanguage program that calculates circular paths on the Look game board.*

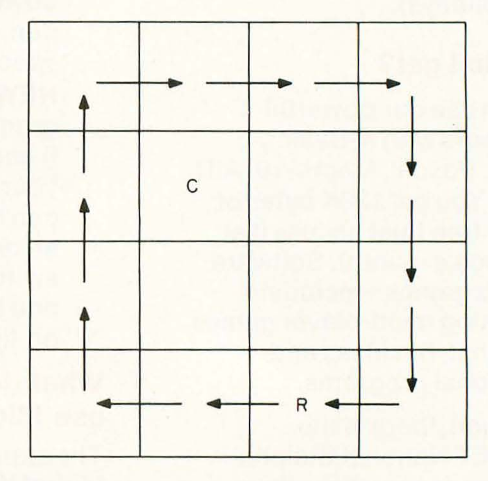


Figure 2: *Path computed by the CIRCLE program (listing 1). CIRCLE creates circular paths for R on the game board, which may or may not intersect with C. It is therefore undecidable whether or not CIRCLE computes a path leading to C.*

```
EXHAUST:
200 REPEAT LOOP
210 STEP W ; IF FOUND THEN STOP
220 UNTIL W BARRIER ;
230 REPEAT LOOP
240 STEP S ; IF FOUND THEN STOP
250 UNTIL S BARRIER ;
260 REPEAT LOOP
270   REPEAT LOOP
280   STEP E ; IF FOUND THEN STOP
290   UNTIL E BARRIER ;
300 STEP N ; IF FOUND THEN STOP ;
310   REPEAT LOOP
320   STEP W ; IF FOUND THEN STOP ;
330   UNTIL W BARRIER ;
340 STEP N ; IF FOUND THEN STOP ;
350 UNTIL N BARRIER ;
360 STOP
```

Listing 2: *Pseudolanguage program that makes an exhaustive sweep through every square on the Look board.*

R is now in the proper lower left position to begin looking for C by systematically visiting every square. This is done by moving N after every E or W BARRIER is found as shown in figure 3.

This version of the program for R illustrates two conceptually important features. Indeed, this program is called an *algorithm* because (1) it will systematically carry out the basic actions in a deterministic (predictable) manner every time it is executed, and (2) it will reach a STOP statement every time it is run. The question remains, however: will this program (algorithm) find C every time?

Looking for C

The program for exhaustive search lacks a certain elegance. For example, the sophistication of R could be increased to add subroutine capability:

```
        SUBROUTINE MOVE: (X,Y)
1000    REPEAT LOOP
1010    STEP X; IF FOUND THEN STOP;
1020    UNTIL Y BARRIER;
1030    RETURN
```

This would reduce program size and complexity by using pieces of the program iteratively. Such an improvement may benefit a programmer or reduce the cost of building robots, but does nothing to improve the concept of computing.

The EXHAUST program becomes easier to understand and write when additional control is supplied. However, the addition of subroutines, interrupts, and other sophisticated features does nothing to increase the computational power of robots. This is an important fundamental concept:

Hypothesis 3: Every function that can be computed, can be computed by a robot with only three control operations: (1) sequence, (2) looping, (3) conditional branching.

If true, this means that every solution to the Look puzzle is possible with the simple machine designed here. There is no path through Look that cannot be computed with the power of robot R. Does this mean that every computation in Look is computable by R? In this specific game, the answer is yes. We have not proven the above hypotheses, but they can be supported by evidence.

What Are the Limits?

What is *not* computable, if such a simple machine (R) is able to compute every function in Look? (This corresponds to finding every path from R to C.) If internal barriers are added to Look as shown in figure 4, does R need more power? The answer is no. A larger, more sophisticated program may be required, but it can be constructed from the same simple building blocks as before.

Suppose that an attempt is made to fool robot R by removing C entirely (see figure 5). What becomes of algorithm EXHAUST? Reexamination of the algorithm shows that the program eventually halts when every square has been searched by R at least once. The STOP action executed when C is located is a different STOP than the one executed when C is missing from the game

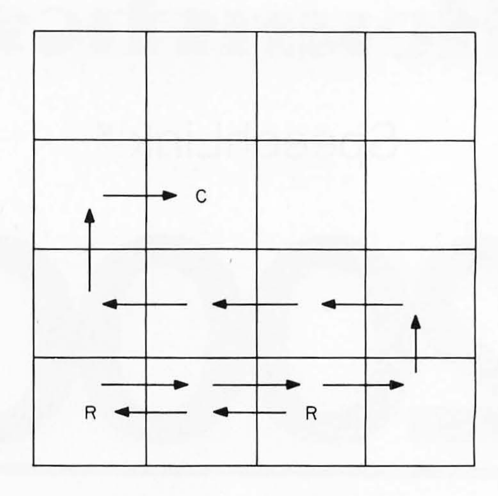


Figure 3: *The exhaustive sweep solution is an inelegant but effective method that systematically visits every square on the board, looking for C.*

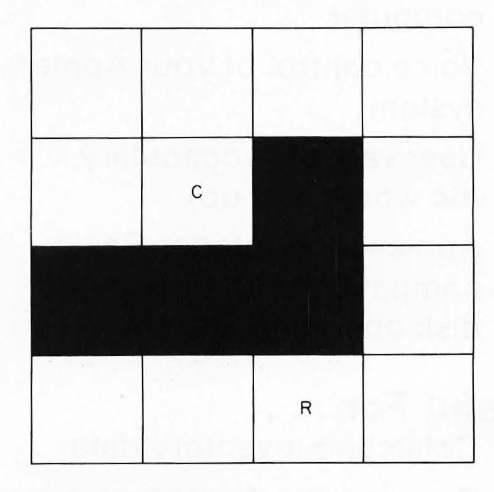


Figure 4: *Adding an internal barrier to the Look game. R does not need any more computing power to solve such a layout, but the program may have to be more sophisticated.*

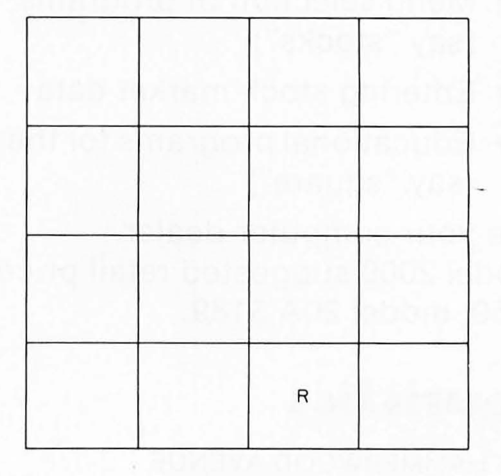


Figure 5: *Removal of the target C from the game. Although R can no longer find C, the program will still halt, and through suitable adjustments, the program can tell whether or not C was found.*

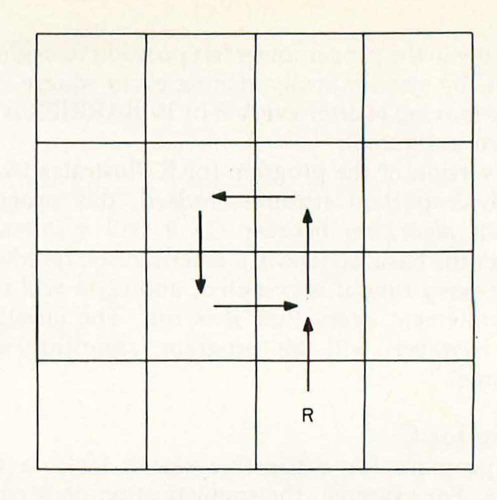


Figure 6: *A heuristic technique for finding C. The programmer has assumed that C is more likely to be found in the center squares, and has thus accelerated the search at the expense of an occasional failure.*

board. Can it be known which stop is executed when EXHAUST halts?

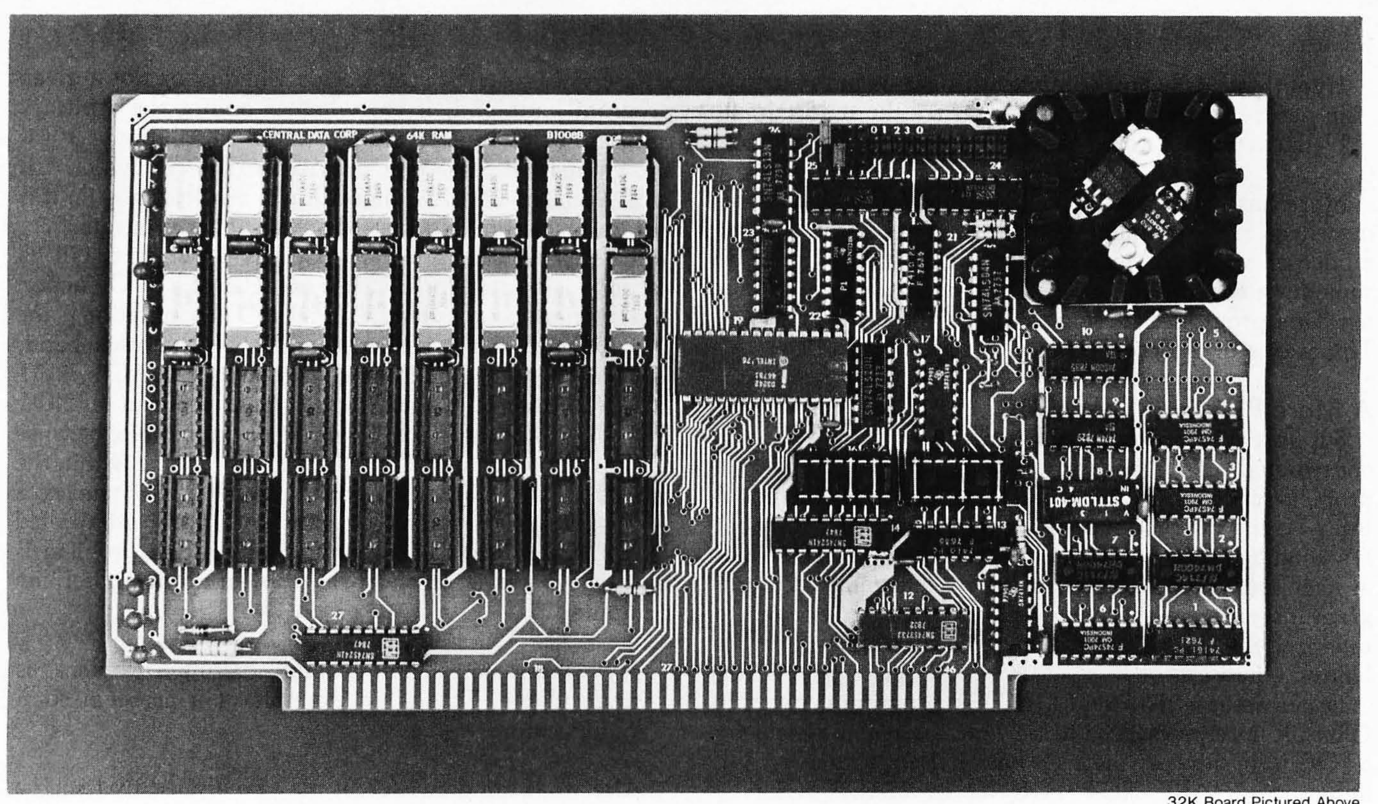
Suppose lines 210, 240, 280, 300, 320, 340, and 360 in listing 2 are modified to display the condition code setting when a STOP is executed. Then when the robot halts, the condition code can be examined to see if it says FOUND or NOT FOUND.

Indeed, R can be built cleverly enough so that it stops and informs you of its condition. This requires that R eventually stop. When it stops, it is asked whether or not it has found a path to C. This leads to another important concept in computing:

> *The Halting Problem:* A robot that computes an algorithm must eventually halt. If a robot tries to compute a function (ie: find a path) that does not guarantee the termination of its search, the robot is computing an *undecidable* function.

Normally, undecidable functions are avoided in computing. Often, however, the risk of encountering a nonterminating search is not great, and thus the rules can be relaxed to speed up the robot. For example, suppose that the EXHAUST algorithm is replaced by a faster heuristic. That is, the search strategy is changed as follows: the exhaustive search procedure is too slow. Its speed can be increased by increasing the robot's speed (technological improvement in equipment), or by decreasing the search space (eliminating the number of squares considered). Perhaps the cheese is in the central squares most of the time. If so, a nearly perfect batting average can be obtained by searching the middle four squares only. Figure 6 suggests one possible heuristic for computing a path to C.

Perhaps the "four-square" heuristic will locate C, perhaps not. This approach may seem too casual, but interestingly enough, much of the software in contemporary systems is of this nature. That is, many programs are heuristic in nature rather than algorithmic, because they have reduced their search space to only the most probable paths. One way of defining a heuristic is as "a procedure for finding the solution *most* of the time."



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Hypothesis 4: Many computer programs are heuristic in nature because they do not satisfy the halting problem, or do not cover the search space of solutions.

More has been required of the little robot than is required of real computer programs. Thus, R is a good model of what machines can do. Still, there must be something R cannot compute. In fact, there is: R cannot tell if its program is an algorithm or merely a heuristic. This is one of the cornerstones of computing.

A More Powerful Robot: GR

Suppose a more powerful generalized robot, GR, is constructed. GR is basically like R, except GR solves a problem called DECIDE. This new game is played as follows: the instructions for a program written in robot R's language (eg: the EXHAUST problem) are given GR as its inputs. Thus, GR plays the DECIDE game on a program instead of a checkerboard. GR is smart enough to interpret the instructions directly and to determine the halting condition of R.

Let us assume that the EXHAUST program is given to GR. GR interprets EXHAUST and, when it reaches a STOP, announces that R has halted. Further, GR announces HALT NOT FOUND or HALT FOUND, depending on the condition code setting of R. In fact, GR is a general robot because it can interpret programs for other robots. In a sense, GR can simulate R because it can interpretively execute any program which can be written for R:

Hypothesis 5: Any machine GR that can simulate a robot of the power of R is a universal robot. A universal robot is limited in its power, being able to compute only computable functions.

Can a problem be found that is too difficult for GR? It would be interesting to discover if such an uncomputable function exists. GR is quite similar to real computers. For example, an Intel 8080 could be simulated on a Motorola 6800 to perform the functions of a universal robot. Thus, if problems too difficult for GR are discovered, they will also be too difficult for the Intel 8080, Motorola 6809, IBM 370, CDC 7600, or Cray-1!

The Halting Problem Revisited

It was stated earlier that the GR machine can interpret *any* program and decide whether or not it halts. To be more precise, however, a GR robot cannot in general decide whether an *arbitrary* program from R's library of programs will halt or run forever. Notice the emphasis on *any arbitrary* program. A specific program can be examined and it can be determined that it will halt. This was done for the EXHAUST program. However, a decide algorithm is being sought that can be written before any program from R is tried. Thus, the DECIDE program must be smart enough to handle any program it is given. This is where the problem appears. Suppose a program is written in the language suggested earlier for R. This language made R powerful enough to compute anything that robots can compute. Thus, the DECIDE algorithm can be written in this language. The DECIDE algorithm is loaded into a mouse just like R, and it becomes supermouse GR. Now GR can decide whether or not a given program halts and, if so, whether or not the arbitrary program being interpreted has found its solutions. If it is shown that at least one program exists for which GR fails, then the DECIDE algorithm is *undecidable* (ie: it is *not* an algorithm). In fact, there is such a program.

If the DECIDE program *itself* is input into GR, a paradox is created for GR. If it executes to a STOP action and announces a HALT FOUND termination, the DECIDE program has succeeded. If, on the other hand, GR reaches a STOP and announces HALT NOT FOUND, then GR must itself have reached a NOT FOUND condition. This, however, is impossible, because GR cannot reach a FOUND termination point within the loaded DECIDE algorithm at the same time it reaches a NOT FOUND termination point within the interpreted DECIDE algorithm. Therefore, the DECIDE problem is unsolvable and is, in short, a problem no computer can compute:

Hypothesis 6: The general halting problem is undecidable. This is an example of a problem computers cannot solve.

After that mind twister, it may be argued that such a problem is of no practical significance. Unfortunately, the halting problem is completely analogous to several important practical problems in computing. Here are a few:

Hypothesis 7: A robot GR that can test any other robot R to determine if R is malfunctioning is impossible to build.
Hypothesis 8: A robot GR that can examine any other robot and determine if R is secure (impenetrable by a team of spies) is impossible to build.
Hypothesis 9: A robot GR that can examine a programming language robot R and determine if it is without ambiguity is impossible to build.

In essence, it has been illustrated that computers have their limits regardless of their size, speed, number of registers, or sophisticated instruction sets. This notion is summarized in the next hypothesis:

Hypothesis 10: Progress in computing has led to microcomputers and circuits that still cannot solve the same problems that earlier computers could not solve.

In other words, computing has advanced in a technological sense only, and not in a conceptual sense. The limitations of computing remain the same: the power of computing is the same.

All computers do essentially the same thing. Some are easier to program because they have high-level instructions. Some are faster because their organizations are more efficient. However, the fundamental problems of computing remain.

Difficult Problems

Fable: An old man was about to send his son into the world to travel. He bent over and wheezed into his proud son's face, "Hear me well, son. The world has

many perplexities."

"Yes, father, I have heard," the young man replied.

"There are two kinds of difficulties that will befall you as you find your way. There are problems that you can solve, and problems that you cannot solve. Be wise and spend your energies only on the problems you can solve."

"I will remember, father."

The Look example can now be returned to, and energy can be applied to solving a problem that it is possible to solve. EXHAUST is a blunt approach to computing a path from R to C. It may be, however, that EXHAUST is the easiest way to compute the location of C.

An algorithm need be only as complex as the problem at hand. Therefore, if the complexity of the problem can be determined, a program can be designed that is no more complex than the problem. Is this possible?

The EXHAUST problem is actually rather uncomplicated. Suppose that initially the cheese is in any square. If there are S squares, the cheese can be in any one of (S-1) squares with probability 1/(S-1). The average number of steps for R to compute along the EXHAUST trail is the average of 1 + 2 + 3 + . . . + (S-1):

$$\text{AVERAGE \#STEPS} = \sum_{\text{STEPS}=1}^{S-1} \frac{\text{STEPS}}{S-1} = \frac{S}{2}$$

Hence, the average number of steps to find C is half the total number of squares in Look.

The problem can be more difficult if C is located at the worst possible location (eg: at (S-1) steps from robot R). This is called the worst case complexity of Look, or SWORST = (S-1). In either the average or worst case condition, the EXHAUST algorithm will complete in a number of steps proportional to S. The complexity of Look is O(S). Since S is a straight line when plotted on graph paper, the Look puzzle is called *linear*:

> **Hypothesis 11:** Linear problems are easy, polynominal problems are more involved, and exponential problems are difficult.

Suppose the Look problem is modified to a more realistic situation. Try to trace the roots of your family tree back to 1600 AD. A great-great . . . great-grandparent is given as a target (C). You must trace your father or mother first, then their father or mother, etc. If your ancestors never practiced incest, remarried, etc, you will have to compare at least 2^R ancestors to find the shortest path back to your roots, where R = number of generations.

The roots problem is difficult because of the exponential growth in the computation. Thus, an exponential problem is hard.

Let us examine another version of Look that poses a test for the power of microcomputers and maxicomputers

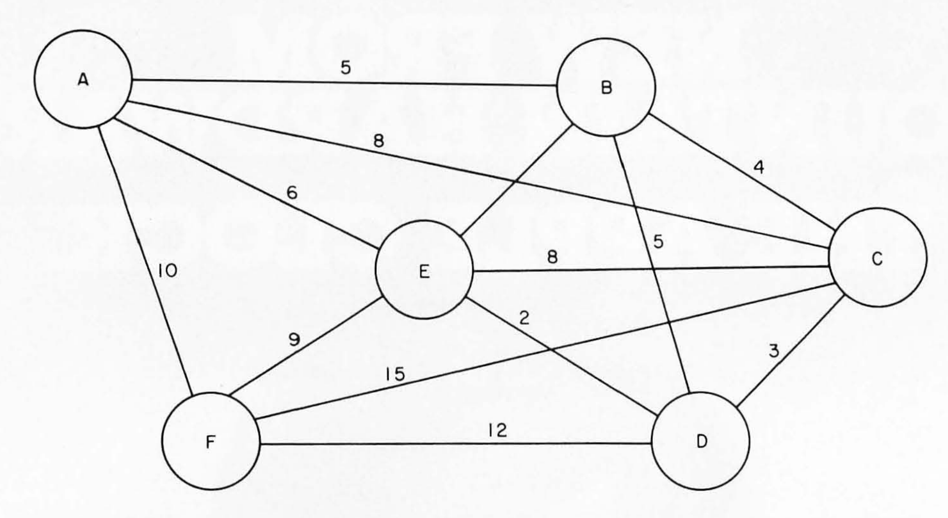


Figure 7: *The traveling salesperson problem. A salesperson wishes to visit all six cities in a given district, once every month. The problem is to compute the shortest path that goes through each city only once.*

alike. Suppose a die is tossed to decide which direction to take: N, W, E, or S. A random number generator is used to produce a random walk around the Look checkerboard. Will such an approach add to the complexity of computation? A random selection introduces chance into the EXHAUST algorithm. This is called a *nondeterministic* procedure (similar to a heuristic), because the exact path may not be reproducible due to the randomness. Eventually the path would be discovered, because there is a nonzero probability that every square will be visited by the meandering robot R.

A nondeterministic procedure may be more complex than a deterministic procedure, or surprisingly it may be less complex, because it reduces the search space statistically. For example, under certain constraining rules, the random walk through Look can produce an answer in $O(\sqrt{S})$ average steps. This is an improvement over the average for EXHAUST. (The maximum or worst case analysis can be much greater, however.)

The most difficult problems faced by computers are known as NP - complete problems. Their algorithms are nondeterministic in nature and perform in a time proportional to some power of the length of their input data. This class of problems can be illustrated by examining the traveling salesperson game.

Traveling Computer Salesperson

Suppose a computer salesperson is given a district with six cities. Each city must be visited once every month. The salesperson wants to compute the shortest path that goes through each city one time only.

A map is shown in figure 7 along with candidate paths between any two cities in the district. Each connecting line is labeled with the distance between cities. What is the shortest route that begins at A and returns to A after passing through every city? Does this problem have a solution? If one path exists, is it unique, or are there others of equal distance?

The complexity of this problem and others like it continues to be a conceptually difficult computation for computers. The difficulty of a number of important problems in computing is just being realized.

This raises some philosophical questions for the future. For example, is the functioning of brain cells a complex problem? If so, is the path established by a thought process representable as a computable function? Even if thought is a computable function, it might also belong to the class of NP - complete problems, and thereby be difficult for computers to handle.

Conclusion

In summary, we must be realistic about the power of computers. There are functions that no computer can compute, and there are functions that require impressive performance to manage. The current crop of microcomputers is no more able to compute a solution to problems than computers of a decade ago. Programmers may, however, have learned new ways to apply computing power in the interim.

On the optimistic side, many practical problems remain to be solved in our society. Computers can help solve them and, due to the microcomputer revolution, there is an opportunity to economically apply this technology to the real world. Along the way, do not forget the limits to computing. ■

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INTEL 32-BIT MICROPROCESSOR RUMORED: As reported in this column last April, Intel was rumored to be working on a 32-bit microprocessor. The project is moving closer to reality as Intel has assigned a part number to the device. It will be called the 8800 (not to be confused with the Altair 8800 computer). The instruction set will not be compatible with Intel's 8-bit or 16-bit microprocessors. The device will be housed in the new 64-pin QUIP (quad-in-line package, see "BYTE News," June 1979) which is cheaper, smaller, and easier to test than dual-in-line packages. The 8800 is reportedly being developed at Intel's facility in Aloha OR. The first test prototypes are reported to have been produced.

TI RF MODULATOR FCC WAIVER GRANTED: The Federal Communications Commission (FCC) has granted Texas Instruments a waiver which permits TI to connect its personal computers to home color television receivers using a radio frequency (RF) modulator. TI originally petitioned the FCC for approval of the RF modulator system in February 1979. The petition was rejected since the regulations required that the complete system be submitted for approval: TI submitted only the RF modulator for approval. Subsequently, Texas Instruments applied for a waiver, provided that the modulator unit met the standards.

The FCC asked other personal computer system manufacturers to comment on the TI request. Radio Shack, Apple Computer, Commodore, Mattel, and Atari responded negatively to the request. Apple, Atari, and Mattel went to great expense to comply with the FCC regulations. The Radio Shack and Commodore systems, which contain integral displays and do not use RF modulators, do not come under the FCC regulations.

The FCC decision further waives testing by the FCC and merely requires that the manufacturer provide the FCC with test results showing compliance. In a related action, the FCC relaxed the standards on RF interference generated by commercial and personal computer systems.

Several personal computer manufacturers that compete with TI have already stated that this waiver will give TI a competitive advantage. Furthermore, several firms publicly questioned the FCC's rule-making methods in making its decision. The likelihood now is that the other personal computer makers will offer systems with RF modulators. It will probably take these manufacturers at least a year to bring out such competing systems.

ULTRA MINI-FLOPPY DRIVE INTRODUCED: Sanyko Seiki Manufacturing Co, Tokyo, Japan, has begun producing samples of an ultra-small floppy disk drive and controller. Called the FMC-100, it uses a 2-inch floppy disk that stores 8 K bytes on one track. It is intended for use in word-processing typewriters and personal computer systems.

THWARTING COMPUTER SOFTWARE PIRATING: A patent (number 4,168,396) has been issued to Robert M Best, Seattle WA, for a "microprocessor which prevents the piracy of computer programs." The device reportedly uses cryptography to protect the software. It is called a *crypto-microprocessor* and stores software in cipher to prevent it from being copied, disassembled, or altered by unauthorized processes. Authorized users can decipher the software with special encryption keys. The patent states that the device is intended primarily for use in personal computer systems.

AC LINE TO TTL INTERFACE IC INTRODUCED: General Instrument Optoelectronics of Palo Alto CA has introduced a low-cost, 8-pin integrated circuit that can be used to directly monitor AC power line circuits and provide transistor-transistor logic (TTL) outputs. The device, therefore, can be used to interface your microprocessor inputs easily and directly to monitor AC power-line-operated devices such as motors, solenoids, relay contacts, and the like. It can also be used to detect power failure and other such applications.

FLAT PANEL TERMINAL DISPLAYS BECOMING AVAILABLE: Computer terminals using flat-screen video displays are getting close to the marketplace. The technology is based on the plasma panel developed by Owens-Illinois, Toledo OH, in the late 1960s. Currently, Interstate Electronics of Anahiem CA, IBM, and Fujitsu have these panels in production. Control Data and NCR are planning large-scale production. IBM now makes approximately 100,000 plasma panels annually, which

are all used in-house. Interstate Electronics currently sells a plasma display terminal that has a 512 by 512 matrix of dots and can display alphanumeric characters and graphics.

Plasma panel makers are working on getting the cost down to the point where these displays can compete with cathode-ray tube (CRT) displays. This is still expected to take several more years.

RANDOM RUMORS: IBM will soon unveil small business (Model 5105) and multiterminal (Model 5130) computers in their 5100 line of microcomputers. The 5105 computer will begin at $4500 and the 5130 will range from $21,500 to $37,500. The basic 5105 will include 16 K bytes of programmable memory, a 960-character video display screen, a magnetic tape cartridge, and a thermal or electrostatic printer. Increasing memory up to 96 K bytes, adding a 1920-character screen, floppy disks, and high-speed printer, and including software packages will raise the 5105 price up to $20,000. It is expected that the 5105 will penetrate the personal computer market to some extent even though it is intended to be an entry-level business computer system . . . . IBM is also rumored to have an intensive research and development effort trying to develop a low-cost alternative to the cathode-ray tube (CRT) screen display. Reportedly they are currently investigating 24 different alternatives. At this time, the most promising is the multiplexed liquid-crystal display . . . . It is rumored that a Japanese electronics company will shortly introduce a $600 personal computer system that is hardware and software compatible with the Radio Shack TRS-80 (Level-II BASIC, 16 K version) . . . . By the end of 1979, over 2,500,000 floppy disk drives had been manufactured.

64 K EPROMS AVAILABLE BY MID-YEAR: Samples of 64 K bit erasable-programmable read-only memory (EPROM), organized as 8 K words by 8 bits, are currently being distributed to customers by Motorola, and production quantities are expected to be shipped by the end of the second quarter of 1980. Motorola has put their 64 K EPROM in a 24-pin package by multiplexing the program supply and chip-enable signals on the same pin. Intel and Texas Instruments, it is believed, will use 28-pin packages for their 64 K EPROMS.

In the meantime, the supply of 2708 EPROMS (1 K words by 8 bits) has caught up to demand and prices are now in the $6 range. The demand for the 2716 EPROM (2 K words by 8 bits) is still very strong, and hence the devices are selling in the $20 to $24 range.

Texas Instruments is currently the largest manufacturer of EPROMs with about 38% of sales. Intel is second with 29%. Fujitsu and Hitachi share third place with 8% each.

AT&T RUNS INTO TROUBLE WITH UNIX: The Association of Data Processing Service Organizations (ADAPSO) has petitioned the US Department of Justice to take action against AT&T's sale of software products, particularly the UNIX operating system. UNIX is one of the most popular software systems for larger Digital Equipment Corp (DEC) PDP-11 machines. Most users feel that UNIX is better than DEC's software.

ADAPSO maintains that AT&T is in violation of a 1956 consent decree. In 1978 the Justice Department authorized an investigation after a similar petition by the Computer and Communications Industry Association (CCIA).

Developed at Bell Laboratories in 1969, UNIX was offered to non-Bell organizations starting in 1973, for $20,000 per computer. In the first half of 1978, Bell reported $580,000 revenues from about 800 non-Bell users.

Whitesmiths Ltd, a New York software house, is currently working on an LSI-11 version of UNIX.

IBM and MCA TO MARKET VIDEO DISK: IBM and MCA Inc have formed a joint venture, called Discovision Associates, to develop, manufacture, and market video disks and players. Until now, MCA has been the sole manufacturer of optical video disks. It is hoped that this will broaden the use of video disk technology in the home entertainment, industrial education, and information fields. The optical disk technology, which uses a laser to record and play back the recorded material, shows promise for use in the computer field. It could be used to store large amounts of read-only digital data in much more compact form than presently is possible on magnetic disks. North American Philips is also marketing a video disk player and RCA plans to introduce a system soon.

MAIL: I receive a large number of letters each month, as a result of this column. If you write to me and wish a response, please include a stamped,self-addressed envelope.

Sol Libes
Amateur Computer Group of New Jersey
(ACG-NJ)
1776 Raritan Rd
Scotch Plains NJ 07076

Indirect Addressing for the 6502

Kenneth Skier
25 Myrtle Ave
Cambridge MA 02138

One of the most attractive features of the 6502 processor—in fact, of the entire 6500 series—is the flexibility offered by its thirteen addressing modes. Unfortunately, these addressing modes are not always available when you want them. Indirect indexed addressing, for example, is available for load and store instructions (and a few others), but not for jump to subroutine (JSR).

A structured approach to programming leads one to write many programs as nested subroutines, and it is not always desirable for the programmer to specify the addresses of those subroutines in advance. For a given application, you may want the user to choose the address of the next subroutine that the processor will execute, or you may want software to calculate or look up that adddress, perhaps in response to sampled input conditions. In either case, you need indirect addressing for the jump to subroutine instruction.

In the 6502, the jump to subroutine instruction has only one addressing mode: absolute. So how can you get what the 6502 does not have?

One solution is to use the jump to subroutine instruction (JSR, hexadecimal 20) in your program, and follow it with two reserved bytes (ie: when you write the program, you do not care what is in those two bytes). The rest of your program follows those two bytes. When your program runs, it will ask the user to specify the address of the next subroutine, or else it will look up or calculate that address according to some algorithm. It will then store that address in the two reserved bytes mentioned earlier (low byte first). When the 6502 processor executes the JSR instruction, it will use the next two bytes for the address of the subroutine it is supposed to execute.

This technique will work, but I avoid it for several reasons. First, it requires writing a program that modifies itself, and a simple error in such a program can cause it to self-destruct or subtly deface itself, not something I would look forward to debugging. Second, such a program may work fine in programmable memory, but it cannot work in read-only memory. The third reason is the clincher: this technique is unnecessary. You can have a program execute a subroutine and calculate or look up its address without requiring that it modify itself.

What is the solution? Use the zero page.

Set aside four consecutive bytes in the zero page of memory. The first part of your program, which presumably initializes I/O (input/-output) ports, variables, flags, table pointers, etc, will write a hexadecimal 20 (JSR) into the first of these zero-page bytes, and a hexadecimal 60 (RTS) into the fourth of these zero-page bytes. (It need not do anything to the second and third bytes.) When it is time for your program to select the address of a subroutine and then perform a subroutine jump to that address, have your program calculate or look up the subroutine's address and then store it, low byte first, in the second and third zero-page bytes mentioned above.

Now your program can jump *to a fixed address:* the address of the first of these four zero-page bytes. Upon arrival at the zero page, the processor will perform a subroutine jump to a new address: the address it previously looked up or calculated. When it finishes executing *that* subroutine, it returns to the fourth of the zero-page bytes, which tells the processor to return to the program that called it. In practice your program jumps to a subroutine with a fixed address, whereupon it jumps to a subroutine with a calculated address. In effect, however, you get indirect addressing for the JSR instruction.

The effect can be impressive.

Using this technique, you can display an address, then let the user

change that address or execute it as a subroutine. It is an effective way to give a GO function to a read-only memory monitor. I have discovered many other applications for this technique in system software and applications programs.

Using this technique, your program can jump to the Xth subroutine in a table: the table would simply be a list of the addresses of eligible subroutines. Assuming that the beginning of your program initialized the first and fourth of the zero-page bytes (to hexadecimal 20 and 60, respectively), your program might look like listing 2.

This technique works quite nicely, but why go to all of that trouble each time you want to call a subroutine? Listing 3 shows a subroutine named CALL SUBROUTINE (X). The programmer need only load the X register with the number of the desired subroutine, and call CALL SUBROUTINE (X). (See listing 4 for a program segment that does just that.)

In other words, you can call a subroutine by a name that you've given it, rather than by its explicit address. To relocate any such subroutine, you need only change its address in the table of subroutine addresses; the routines that call it need not be changed in any way.

Here is one last point. You do not *have* to put the four bytes (20, XX, XX, 60) in the zero page; you can put them anywhere in programmable memory. However, putting them in the zero page lets your program operate on the second and third of these bytes (that is, on the subroutine's address), with the zero-page addressing mode available on many other instructions. Thus, by putting those four bytes in the zero page, you can make your overall program shorter (and probably faster) than it would be if you put those bytes elsewhere in programmable memory.

Incidentally, this technique may be used for any instruction, not just for JSR. To achieve such indirect addressing for other instructions, do not write a hexadecimal 20 in the first byte; write the op code for the instruction you want to execute. (Be sure that your program follows that op code with the appropriate one or two byte operand, and that your program writes a return [RTS, hexadecimal 60] in the byte following that operand, or your program, like Charlie on the MTA [*a legendary subway passenger*...**RSS**], may never return.) In any case, the program that calls this function must do so by executing a subroutine jump to the first of these zero-page bytes, even if those zero-page bytes do something other than call a subroutine. ■

Listing 1: *A program to initialize the zero-page bytes.*

```
LDA     #$20                 Write JRS
STA     zero page byte #1    and
LDA     #$60                 RTS into
STA     zero page byte #4    zero page
            .
            .
            .
remainder of initialize routines
```

Listing 2: *The indirect addressing method discussed can be used to jump to one subroutine in a table of subroutines. If the start of the program initializes the first and fourth byte of the zero-page reference to a jump to subroutine (JSR) command and a return (RTS) command, the coding for using the table might look as above. Note that "Zero Page Byte #3" does not mean address 0003; rather it means the address of the third of the zero-page bytes referred to in this article.*

```
LDA     TABLE, X             Look up address
STA     zero page byte #2    of Xth subroutine
INX                          and copy that
LDA     TABLE, X             address into the
STA     zero page byte #3    zero page
JSR     zero page byte #1    Execute that
                             subroutine
            .
            .
            .
remainder of program
```

Listing 3: *Routine to create subroutine call using zero-page addresses.*

```
LDA     TABLE,X              Look up address
STA     zero page byte #2    of Xth subroutine
INX                          and copy that
LDA     TABLE,X              address into the
STA     zero page byte #3    zero page.
JSR     zero page byte #1    Execute that subroutine.
RTS                          Return to caller.
```

Listing 4: *Shorter program segment to simulate an indirect subroutine jump.*

```
LDX     subroutine #
JSR     CALL SUBROUTINE (X)
            .
            .
            .
remainder of program
```

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Telephone Dialing by Computer

Edward Joyce
4603 Lyceum Dr
San Antonio TX 78229

How would you like to have your computer dial a seven-digit telephone number in about 3/4 of a second? For a small investment in hardware components and construction time, your personal computer can dial a telephone number faster than you can say that number. This article describes the construction and operation of a dual-tone multiple-frequency (Touch Tone) dialing device that interfaces with an ASCII computer terminal and can be used for automatic telephone dialing.

Many practical applications can be designed around an automatic dial feature, but the most obvious is a personal telephone directory. In such a system, a list of frequently dialed telephone numbers and associated names is displayed on the computer terminal. The user selects the number to be dialed by entering a single corresponding character on the computer keyboard (see table 1). A feature that could be incorporated is an option to redial the last number dialed, which would be useful for reaching busy numbers.

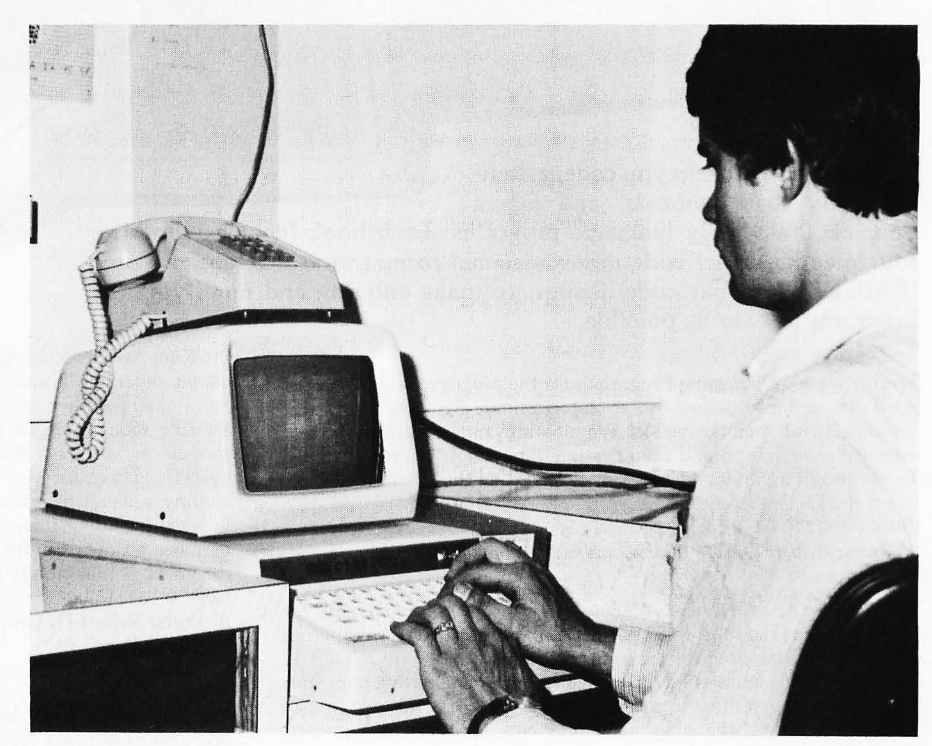


Photo 1: *Dialing the telephone is done by selecting from a menu displayed by the computer on the screen of the video terminal.*

Assuming that you have a microprocessor and an ASCII terminal, the additional hardware that is required can be constructed for less than $20. Furthermore, this Touch Tone interface does *not* require its own I/O (input/output) port, the telephone can be used both automatically and manually, the programming is relatively simple, and either a Touch Tone or rotary-dial telephone can be utilized. *[Note that the telephone exchange to which the line is connected must be capable of interpreting Touch Tones. Some telephone systems (such as those in Peterborough NH) still cannot use Touch Tone dialing....***RSS***]*

Touch Tone Interface

A block diagram of the hardware is shown in figure 1. Note that communication with the Touch Tone device is established *through* the terminal. Specifically, the computer generates tones by sending certain characters to the terminal. Since most ASCII codes have predesignated meanings (for example, hexadecimal 30 is the digit 0, hexadecimal 41 is the letter A, etc), it is necessary to assign the Touch Tone controls to ASCII codes not used by your terminal. A logical choice for these assignments is among the thirty-two ASCII control codes (hexadecimal 00 thru hexadeci-

About the Author
Ed Joyce attended the University of Pittsburgh and Trinity University where he completed a master's degree in Computing and Information Sciences. Since 1973 he has worked as a professional programmer with interests in multiprocessor microprocessor systems and speech recognition. Currently he is employed at Small Systems Engineering Dept, Data Point Corp in San Antonio TX. His recreational interests are backpacking and motorcycle touring.

Touch Tone is a registered trademark of the Bell System for its dual-tone multiple-frequency signaling equipment.



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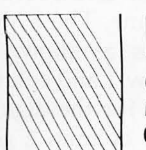
Make no mistake about it. The freshman students in the small systems business can't begin to compete with this year's honor graduate. The SuperBrain. The only system at the top of its class in price and performance

System Specifications

CPU	
Microprocessors	Twin Z80A's with 4MHZ Clock Frequency. One Z80A (the host processor) performs all processor and screen related functions. The second Z80A is "down-loaded" by the host to execute disk I/O. When not processing disk data, the second Z80 may be programmed by the host for other processor related functions.
Word Size	8 bits
Execution Time	1.0 microseconds register to register
Machine Instructions	158
Interrupt Mode	All interrupts are vectored.
Floppy Disk	
Storage Capacity	320K total bytes formatted on two double density drives. Optional external 10-300 megabyte hard disk storage is available using optional S-100 bus adaptor.
Data Transfer Rate	250K bits/second
Average Access Time	250 milliseconds. 35 milliseconds track-to-track
Media	5 1/4 inch mini-disk
Disk Rotation	300 RPM
Internal Memory	
Dynamic RAM	64K bytes dynamic RAM.
Static RAM	256 bytes of static RAM is provided in addition to the main processor RAM. This memory is used for program and/or data storage for the auxiliary processor.
ROM Storage	1K bytes standard. Allows ROM "bootstrapping" of system at power-on. ROM storage is 2708 compatible and may be reprogrammed by the user for custom applications.
CRT	
Display Size	12-inch, dynamically focused. P4 phosphor
Display Format	25 lines x 80 characters per line
Character Font	8 x 8 character matrix on a 8 x 12 character field
Line Drawing Characters	Eleven special graphics symbols used for form generation.
Display Presentation	Light characters on a dark background. Reversible through keyboard/program selection.
Bandwidth	20 MHZ.
Cursor	Reversed image (block cursor)
Communications	
Screen Data Transfer	Memory-mapped at 38 kilobaud. Serial transmission of data at rates up to 9600 bps.
Auxiliary Interface	Universal RS-232 asynchronous. Synchroncus interface optional.
Parallel Interface	Radio Shack TRS-80 compatible.
S-100 Bus	Printed circuit edge connector provided for connection of optional S-100 bus adaptor.
Transparent Mode	Enables display of all incoming and outgoing control codes.
Parity	Choice of even, odd, marking, or spacing
Transmission Mode	Half or Full Duplex. One or two stop bits
Addressable Cursor	Direct positioning by either discrete or absolute addressing
System Utilities	
Disk Operating System	CP/M
DOS Software	An 8080 disk assembler, debugger, text editor and file handling utilities.
Optional Software	
FORTRAN	ANSI standard. Relocatable, random and sequential disk access.
COBOL	ANSI standard. Relocatable, sequential, relative and indexed disk access.
BASIC	Sequential and random disk access. Full string manipulation, interpreter.
Application Packages	Extensive software development tools are available including software for the following applications: Payroll, Accounts Receivable, Accounts Payable, Inventory Control, General Ledger and Word Processing.
Keyboard	
Alphanumeric Character	Generates all 128 upper and lower case ASCII characters.
Special Features	N-Key Rollover, Automatic repeat (at 15 CPS), Keyboard lock/unlock.
Numeric Pad	0-9, decimal point, comma, minus and four user-programmable function keys.
Special Functions Keys	Up to 64 user-defined two-key function sequences.
Cursor Control	Up, down, forward, backward, and home.
Internal Construction	
Cabinetry	Structural foam
Component Layout	Two board modular design. All processor related functions and hardware are on a single printed circuit board. All video and power related circuits on a separate single board. These two boards are interconnected via a single 22-pin ribbon cable.
Mounting	CRT and two circuit boards mounted to base. CRT in a rigid steel frame. Disk Drive assembly mounted into upper cover for ease of servicing.
Environment	
Weight	Approximately 45 pounds
Physical Dimensions	14 5/8" (H) x 21 7/8 (W) x 23 1/8 (D)
Environment	Operating: 0° to 50° C Storage: 0° to 85° C; 10 to 95% rel. humidity - non condensing.
Power Requirements	115 VAC, 60 HZ, 1 AMP (optional 230VAC/50HZ model available)

* Specifications subject to change without notice

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.		
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A	828-0553	Computer Shop
B	227-8341	Fire Dept
C	227-7201	Police Dept
D	824-5222	Dial-A-Prayer
.		
.		
.		
Z		Last Number Dialed

Table 1: *Typical information displayed on the computer terminal in an automatic telephone dialing system that can be set up using the dialing device described in this article. The user types a single-character access code on the computer keyboard and the system dials the corresponding telephone number automatically.*

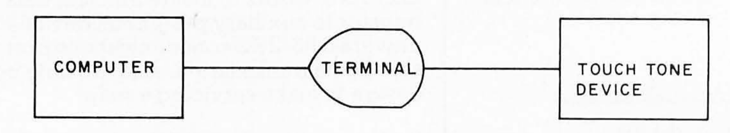
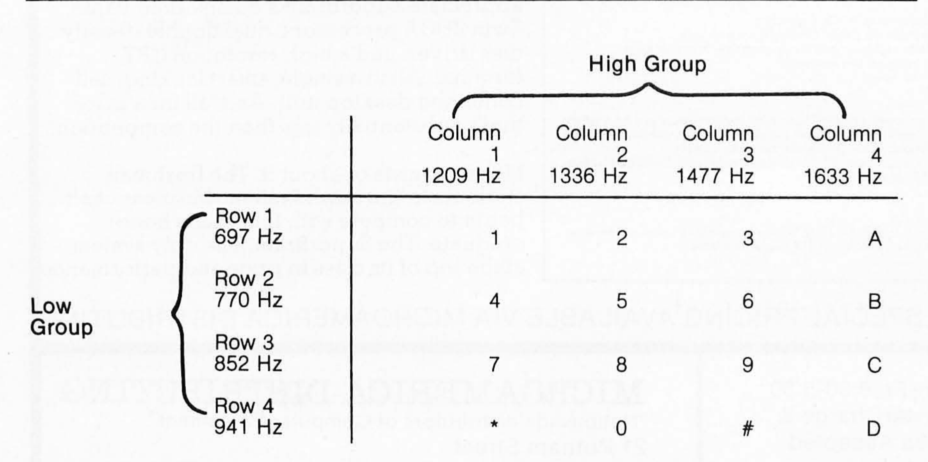


Figure 1: *Block diagram of connections in the system.*



		High Group			
		Column 1 1209 Hz	Column 2 1336 Hz	Column 3 1477 Hz	Column 4 1633 Hz
Low Group	Row 1 697 Hz	1	2	3	A
	Row 2 770 Hz	4	5	6	B
	Row 3 852 Hz	7	8	9	C
	Row 4 941 Hz	*	0	#	D

Table 2: *Row and column input lines on the integrated tone dialer device, associated tone frequencies, and corresponding digits or signaling codes derived from the combination of two tones of different frequency.*

mal 2F). Most terminals use ten or twelve of these thirty-two codes for predesignated functions (such as line feed and carriage return). However, there are generally about twenty codes that can be used for other purposes. The Touch Tone device described here will use ten of these control characters.

How are the ASCII control characters sent to the Touch Tone device? By utilizing the decoding logic of the terminal. In units such as the Southwest Technical Products Company CT-64, all thirty-two control characters are decoded by the terminal. Some of the control characters are acted upon by the terminal (eg: line feed); however, those which are not used are brought out to labeled pads on the main circuit board for custom use and user-defined functions. For tone generation, simply choose ten of these user-defined control characters and connect the appropriate pins to the corresponding pins of the Touch Tone device.

Terminals which do not decode the unused ASCII control characters or do not present at least ten pins for user-defined functions require construction of a control-character decoder. The control-character decoder runs in parallel with the terminal and requires only two integrated circuits.

Touch Tone Generating Circuit

Now that the method of interfacing the terminal with the Touch Tone circuit has been described, the actual operation of the Touch Tone device will be discussed. Basically, it consists of two medium-scale integration (MSI) quad $\overline{S}-\overline{R}$ latches, a Mostek integrated tone dialer, and a relay for switching the Touch Tone device to the telephone.

The integrated tone dialer requires two inputs (a row input and a column input) to generate a tone. These input signals activate tones as shown in table 2. Activating row 1 and column 1 generates the tones for the digit 1; activating row 3 and column 2 generates the tones for the digit 8, etc.

Circle 75 on inquiry card.

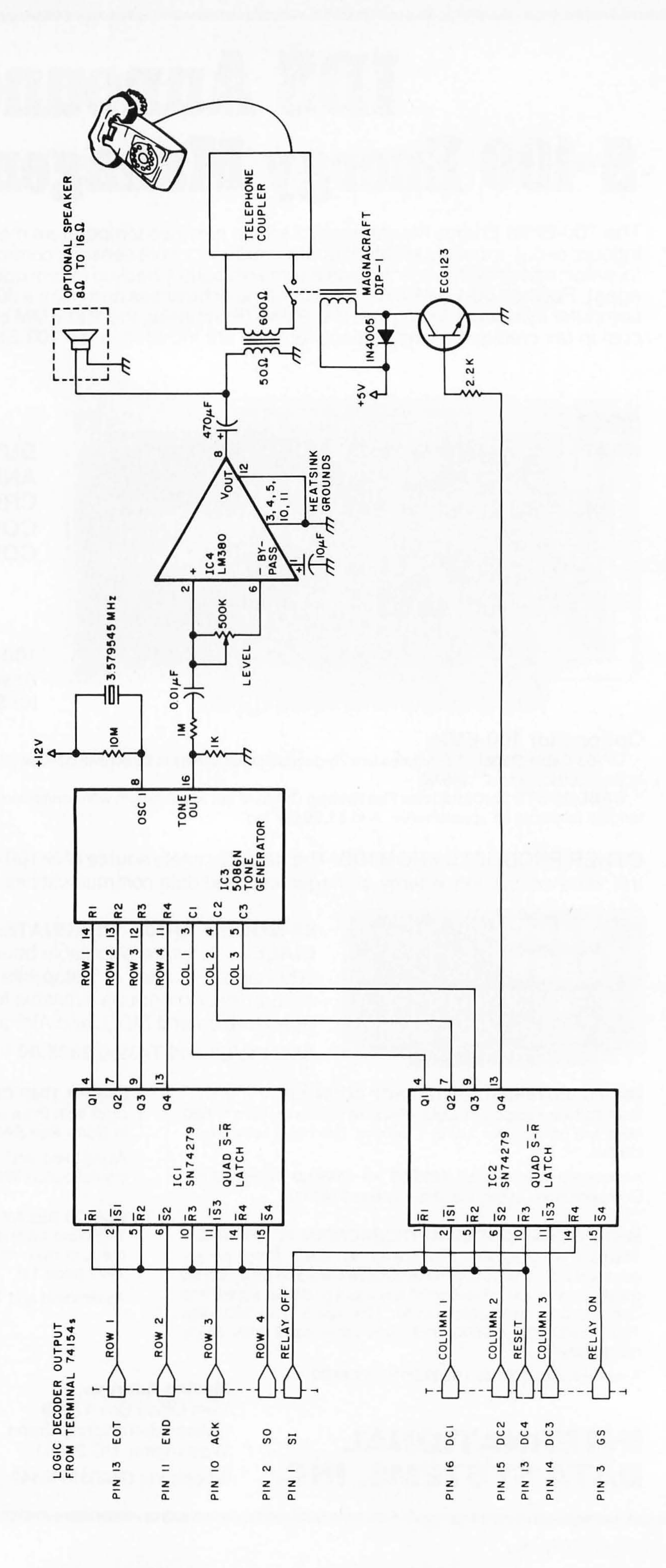


Figure 2: *Schematic diagram of the dual-tone multiple-frequency (Touch Tone) telephone dialing circuit. Connections to the terminal apply to the Southwest Technical Products Corp CT-64 unit. Terminals which do not decode the entire ASCII character set may require additional decoding circuitry for use with the telephone interface. The isolating telephone coupler is required for connection to the telephone line of devices which have not been given approval by the Federal Communications Commission.*

The tone combinations for the characters A, B, C, and D (column 4 of table 2) do not have corresponding keys on a normal telephone Touch Tone pad but are reserved for future use. Since you will be generating only the tones 0 thru 9, only inputs for columns 1 thru 3 and rows 1 thru 4 will be needed. Hence, seven ASCII control characters will be needed to activate the three columns and four rows. Use of the other three ASCII control characters (for a total of ten) is discussed later.

The purpose of the latches (IC1 and IC2) is to hold the output state of the logic decoder of the terminal. Since the terminal processes only one character at a time and the tone dialer requires the simultaneous presence of two input signals, the latch holds the first input from the terminal while the second input is being transmitted. There is a latch for each column and row of the integrated tone dialer. The latch IC2 is also used to control a relay for attaching the tone device to the telephone. A schematic of the complete Touch Tone generating circuit is shown in figure 2.

The output of the integrated tone dialer goes into an isolating coupler connected to a telephone. The coupler must be approved by the Federal Communications Commission, and it is required for user con-

Number	Type	+5 V	GND	+12 V
IC1	74279	16	8	
IC2	74279	16	8	
IC3	5086N		6	1,7
IC4	LM380		7	14

Table 3: *Power supply connections for integrated circuits in figure 2.*

structed devices which attach to the telephone company's equipment. Approved couplers can be purchased for approximately $5 from electronic supply houses, or they can be leased from the telephone company for $2 to $4 a month.

As previously mentioned, there are three more ASCII control characters required by the Touch Tone device. These perform the reset, relay on, and relay off functions. The reset control is used to turn a tone off after it has been turned on (the tone combination is turned on by activating a row/column combination). (That is, once a row and column have been turned on, they remain on until a reset is issued.) Reset is also used to clear the latches after powering up the circuit. Note that the control character used for reset (pin 13 of the terminal 74154) is connected to the reset pin of the latch for each row and column control (IC1 and IC2). A single reset operation clears all of the row and column latches. This is more convenient than clearing the row and column latches individually.

The relay on and relay off controls are used to make connection to and disconnect from the telephone. The Touch Tone device is connected to the telephone coupler immediately before dialing and is disconnected from the terminal immediately after dialing. This prevents random signals and noise (such as that generated at power on) from entering the telephone line from the terminal.

In my system, the power supply for the Touch Tone device was taken from the terminal's power supply. After the Touch Tone generating circuit has been constructed, the volume output from the integrated tone dialer should be adjusted with a VU meter so that it will be in the range of −6 to 0 dB. Output signals less than −6 dB in level will not be recognized by the telephone company equipment. Output levels greater than 0 dB cause cross-modulation into other phone lines. The general operation of the Touch Tone device can be tested off-line by entering the various control characters with the terminal in full duplex mode.

Dialing

Once the hardware is functioning correctly, dialing is simple. Basically, it consists of the following steps:

- Turn the line connection relay on (send the control character for *relay on* to the terminal).
- Turn column on for Nth digit (send the control character for the column of digit N to the terminal).
- Turn row on for Nth digit (send the control character for the row of digit N to the terminal).
- Wait 40 ms.
- Turn tone off (send the control character for *reset* to the terminal).
- Wait 40 ms.

  The preceding steps are performed once for each digit of the telephone (for example, seven times for a local telephone number).
- Turn relay off (send the control character for *relay off* to the terminal).

Note that from the perspective of the microprocessor unit, generating Touch Tones is accomplished in the same manner as displaying characters on the terminal screen. The 40 ms delays are minimum times required by the telephone company equipment. A tone must stay on for at least 40 ms, and there must be at least a 40 ms delay between tones.

Summary

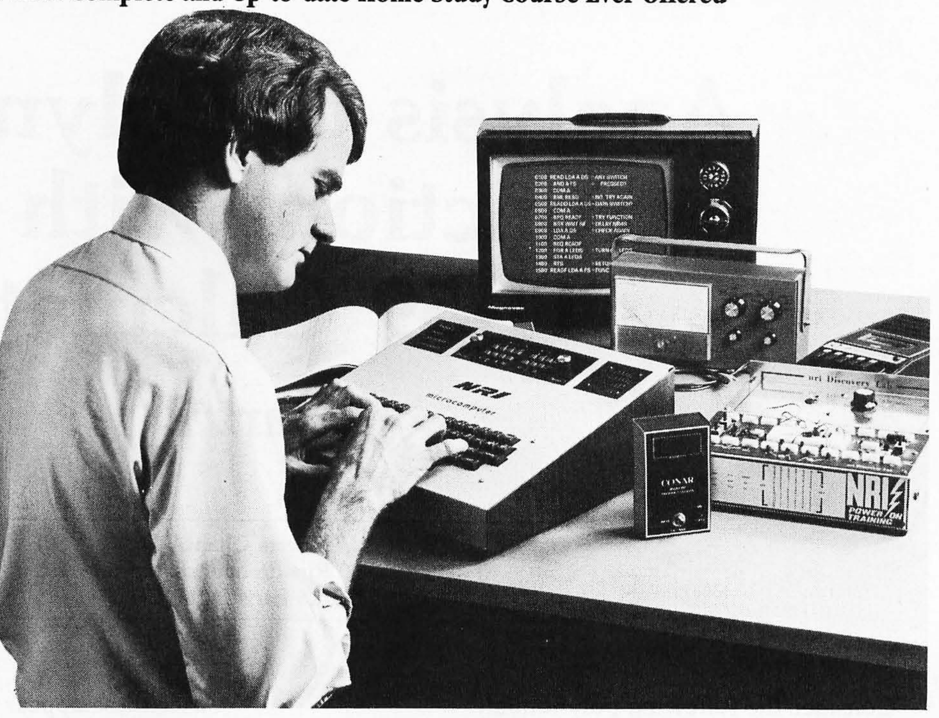
This Touch Tone interface, used in conjunction with a microprocessor and an ASCII terminal, is an example of a practical computer application in communications. I advise personal computing enthusiasts who construct their own Touch Tone devices to be most careful when debugging the software. Sending random sequences of digits through a Touch Tone interface can be a painful way to debug your program (although the pain may not be felt until the telephone bill arrives a few weeks later). ■

Acknowledgements

I am grateful to Dink Stockert, Dr David Crouch, and Carl Zettner for their assistance in the design and construction of the hardware. Lynn Mason, of Cimarron Information Systems Inc, was very generous in providing a computer system for preparation of the text of this manuscript.

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Analysis of Polynomial Functions with the TI-59 Calculator

Part 2

Pierre Chancé
20 Rue de Longchamp
75116 Paris FRANCE

Consider the following polynomial:

$$P(x) = x^4 - 8x^2 + 7$$

For $P(x) = 0$ it is essential to study the characteristic elements, derived polynomials $P'(x)$ and $P''(x)$, and automatically plot the function curve. The procedure is as follows:

1. Read the magnetic card of the main program in groups 1 and 2.
2. Initialize by depressing key A.
3. Enter each of the coefficients with the keys. Start with the coefficient for x^6 by depressing key B each time. A 0 is entered for any term not having a power of x. Thus, you can perform the sequence 0 B, 0 B ,1 B, 0 B, —8 B, 0 B, 7 B.
4. Depress key C.

Depressing key C causes the processing of $P(x)$ to its conclusion with no other intervention.

When reading listing 1, the following are seen successively, separated by program spaces:

- the column of the seven given coefficients or the 0s which replace them
- the group of the lower boundary *a* and upper boundary *b*
- the group of interval $(b - a)$ and increment $\triangle x$
- the indication of the maximum error

After these appear the following results:

- the group of roots followed by the series 9. 999...? that indicates the end of determination of the roots
- the table of the thirty-nine values of x
- the table of the thirty-nine values of $P(x)$

If it is desired to retain the data for $P(x)$ to plot the function curve later, this is the time to record it in groups 3 and 4.

The procedure for the first derived polynomial is even simpler:

1. Depress key B′ once; this causes all the coefficients of $P'(x)$ to be printed one after the other.
2. Depress key C.

The second derived polynomial is obtained in the same manner. The same applies for the derivatives of order n, provided the polynomial remains derivable. Notice that it is useless to reinitialize to change from one polynomial to the next.

Plotting the Function Curve

By convention, hereafter designate the data used in plotting the function curve as listing 2. It can be the table of values of $P(x)$ already recorded or any other that could be substituted for reasons that will be discussed. The plot itself will be designated figure 1.

Text continued on page 134

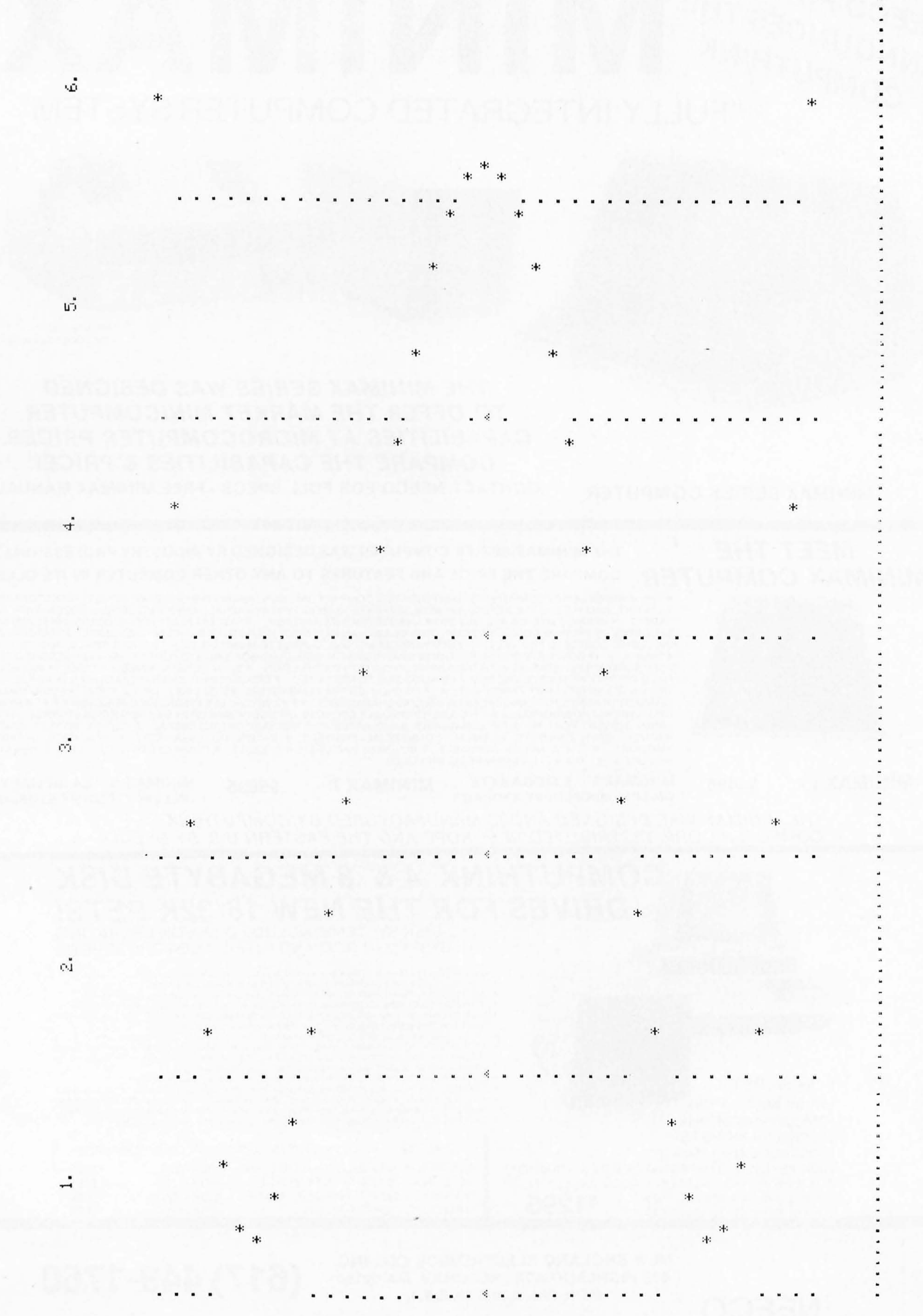
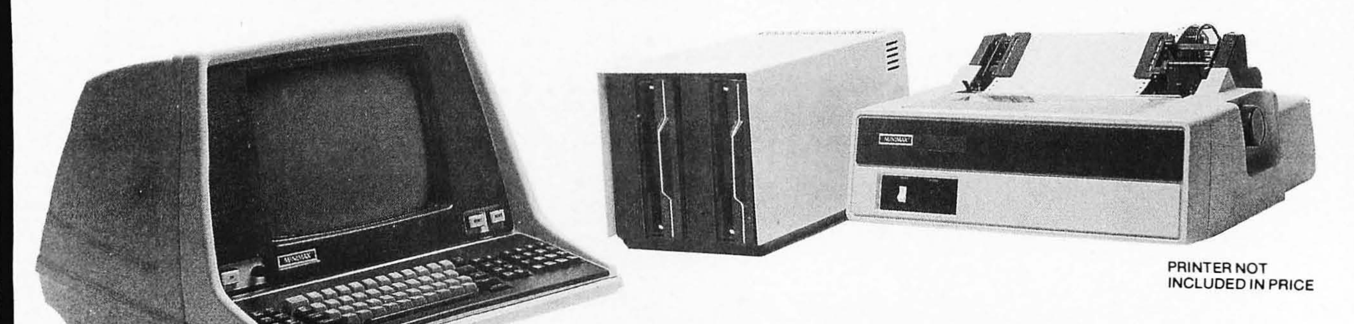


Figure 1: *The six segments of output from the TI-59 that define the function curve.*

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- System does not utilize IEEE or USER Port, system functions directly from memory port
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Listing 1: *A listing containing the data and error specification for a six-degree polynomial, P(x). Thirty-nine values of x are also printed along with the corresponding values of P(x) calculated for each value of x.*

```
             0.                 0.
             0.                 0.                   0.
             1.                 0.                   0.
             0.                 4.                   0.
            -8.                 0.                   0.
             0.               -16.                   3.
             7.                 0.                   0.
                                                    -4.

-3.828427125
 3.828427125                   -3.
                                3.         -2.154700538
                                            2.154700538
 7.656854249
 .3828427125                    6.
                                0.3         4.309401077
                                            .2154700538
    0.000001
                          0.000001
                                               0.000001
  -2.6457516
-.9999998053          -2.000000095
 1.000000232          .0000002725           -1.15470057
 2.645751297          2.000000068           1.154700295
   9.9999999 99?        9.9999999 99?         9.9999999 99?

-3.637005769   21          -2.85    21  -2.046965511   21
-3.445584412   22           -2.7    22  -1.939230485   22
-3.254163056   23          -2.55    23  -1.831495458   23
  -3.0627417   24           -2.4    24  -1.723760431   24
-2.871320344   25          -2.25    25  -1.616025404   25
-2.679898987   26           -2.1    26  -1.508290377   26
-2.488477631   27          -1.95    27   -1.40055535   27
-2.297056275   28           -1.8    28  -1.292820323   28
-2.105634919   29          -1.65    29  -1.185085296   29
-1.914213562   30           -1.5    30  -1.077350269   30
-1.722792206   31          -1.35    31  -.9696152423   31
 -1.53137085   32           -1.2    32  -.8618802154   32
-1.339949494   33          -1.05    33  -.7541451884   33
-1.148528137   34           -0.9    34  -.6464101615   34
-.9571067812   35          -0.75    35  -.5386751346   35
-.7656854249   36           -0.6    36  -.4309401077   36
-.5742640687   37          -0.45    37  -.3232050808   37
-.3828427125   38           -0.3    38  -.2154700538   38
-.1914213562   39          -0.15    39  -.1077350269   39
        5.-13  40          -9.2-12  40        -8.9-12  40
 .1914213562   41           0.15    41   .1077350269   41
 .3828427125   42            0.3    42   .2154700538   42
 .5742640687   43           0.45    43   .3232050807   43
 .7656854249   44            0.6    44   .4309401077   44
 .9571067812   45           0.75    45   .5386751346   45
 1.148528137   46            0.9    46   .6464101615   46
 1.339949494   47           1.05    47   .7541451884   47
  1.53137085   48            1.2    48   .8618802153   48
 1.722792206   49           1.35    49   .9696152423   49
 1.914213562   50            1.5    50   1.077350269   50
 2.105634919   51           1.65    51   1.185085296   51
 2.297056275   52            1.8    52   1.292820323   52
 2.488477631   53           1.95    53    1.40055535   53
 2.679898987   54            2.1    54   1.508290377   54
 2.871320344   55           2.25    55   1.616025404   55
   3.0627417   56            2.4    56   1.723760431   56
 3.254163056   57           2.55    57   1.831495458   57
 3.445584412   58            2.7    58   1.939230485   58
 3.637005769   59           2.85    59   2.046965511   59

 76.15249512   21     -11.749125    21   2.856734472   21
 52.96920178   22         -8.883    22   2.427281539   22
 34.42252761   23      -6.381375    23   2.021042278   23
 19.94856125   24         -4.224    24   1.638016689   24
 9.015614845   25      -2.390625    25   1.278204772   25
 1.124224037   26         -0.861    26   .9416065276   26
-4.192852014   27       0.385125    27   .6282219549   27
-7.370630645   28          1.368    28   .3380510543   28
-8.811905689   29       2.107875    29   .0710938257   29
-8.887247468   30          2.625    30  -.1726497308   30
-7.935002802   31       2.939625    31  -.3931796153   31
-6.261295001   32          3.072    32  -.5904958277   32
-4.140023871   33       3.042375    33  -.7645983681   33
 -1.81286571   34          2.871    34  -.9154872364   34
 .5107266897   35       2.578125    35  -1.043162433   35
 2.653524043   36          2.184    36  -1.147623957   36
 4.470520569   37       1.708875    37  -1.228871809   37
 5.848933998   38          1.173    38  -1.286905989   38
 6.708205561   39       0.596625    39  -1.321726497   39
          7.   40          3.68-11  40  -1.333333333   40
 6.708205561   41      -0.596625    41  -1.321726497   41
 5.848933998   42         -1.173    42  -1.286905989   42
 4.470520569   43      -1.708875    43  -1.228871809   43
 2.653524043   44         -2.184    44  -1.147623957   44
 .5107266897   45      -2.578125    45  -1.043162433   45
 -1.81286571   46         -2.871    46  -.9154872364   46
-4.140023871   47      -3.042375    47  -.7645983681   47
-6.261295001   48         -3.072    48  -.5904958277   48
-7.935002802   49      -2.939625    49  -.3931796153   49
-8.887247468   50         -2.625    50  -.1726497308   50
-8.811905689   51      -2.107875    51   .0710938257   51
-7.370630645   52         -1.368    52   .3380510543   52
-4.192852014   53   -.3851250001    53   .6282219549   53
 1.124224037   54    .8609999998    54   .9416065276   54
 9.015614845   55       2.390625    55   1.278204772   55
 19.94856125   56          4.224    56   1.638016689   56
 34.42252761   57       6.381375    57   2.021042278   57
 52.96920178   58          8.883    58   2.427281539   58
 76.15249512   59      11.749125    59   2.856734472   59
```

Text continued:

The procedure is as follows in practice:

1. In groups 3 and 4 read listing 2 mentioned above.
2. In groups 1 and 2 read the magnetic card of the program for the function curve.
3. Initialize by depressing key A.
4. With the keys enter the two extremes envisaged for the curve starting with the lower and then each time depressing key B.
5. Depress key C.

Depressing key C initiates the entire process with no other intervention. The six strips obtained are separated by cutting with scissors, and are assembled with glue or adhesive tape. This is the standard automatic procedure, and nothing prevents the operator from applying it in every case using the data collected in listing 1.

However, you may desire to center the reproduction in a smaller field. When examining the table of values of P(x) obtained, it is obvious that, for registers R_{21} thru R_{25} and R_{55} thru R_{59}, small variations in x cause considerable variations in P(x). In other words, the curve ends with parabolic branches. In the same way a photographer takes a close-up of a subject, you can neglect the infinite range and concentrate on useful details.

For this purpose, you must disconnect automatic operation and gain control of the depth of field. This time, the procedure will be as follows:

1. Reread the card of the main program in groups 1 and 2.
2. Initialize by depressing key A.
3. Re-enter the initial coefficients of R_{16} to R_{10} by each time depressing key B as previously indicated.
4. Switch to programming mode LRN, and perform the few modifications required:

   - Replace the neutral NOP instructions provided for this purpose at statements 087, 096 and 119 by R/S instructions.
   - Replace the initial partition of the interval (*a*, *b*) at statements 120 thru 122 by as many NOP instructions.
   - Replace all occurrences of ϵ with a deliberately excessive number, for example 999...

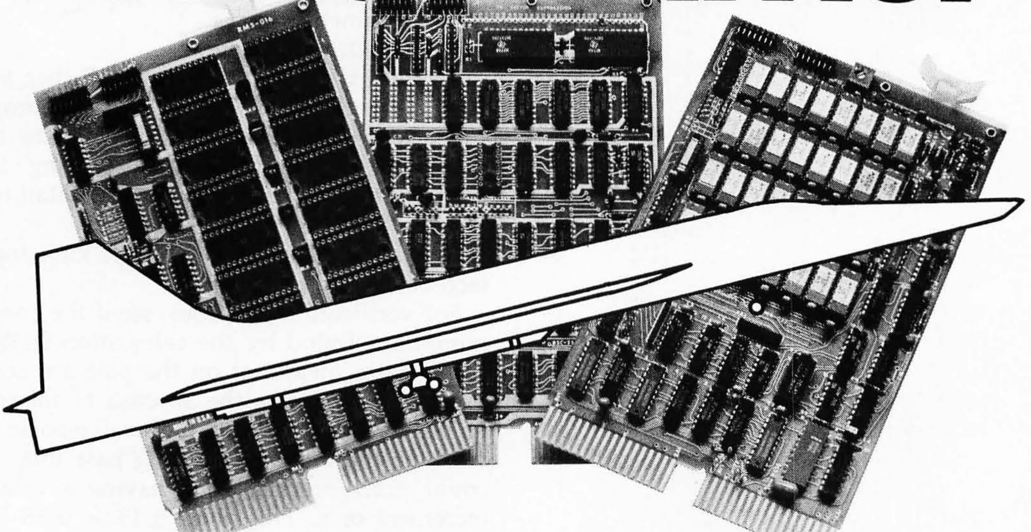
5. Return to the calculating mode, and depress key C. The rest of the program will be executed but will stop whenever useful to permit the entry of a data item of your choice:

   - Boundary *a* with the first stop: here, it will be 3 in absolute value but the calculator will recognize it as negative 3.
   - Boundary *b* with the second stop: it will again be 3.
   - Partition of the interval (*a*, *b*) at the third stop: keep it at 20 on seeing the value of the interval the machine has just printed out after the boundaries.

Naturally, each data entry with the keys is followed by operation of the R/S key to restart the calculation.

What happens now? Without getting involved in a root calculation that is no longer of interest at this point, the

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Listing 2: *Listing of a sample input of data used to plot the function curve.*

```
       0.                  -0.9        34        -8.4224      28
       0.                  -0.75       35   -7.36799375       29
       1.                  -0.6        36       -5.9375       30
       0.                  -0.45       37   -4.25849375       31
      -8.                  -0.3        38       -2.4464       32
       0.                  -0.15       39   -0.60449375       33
       7.                   0.         40        1.1761       34
                            0.15       41    2.81640625       35
                            0.3        42        4.2496       36
      -3.                   0.45       43    5.42100625       37
       3.                   0.6        44        6.2881       38
                            0.75       45    6.82050625       39
       6.                   0.9        46            7.       40
      0.3                   1.05       47    6.82050625       41
                            1.2        48        6.2881       42
                            1.35       49    5.42100625       43
 9999999.                   1.5        50        4.2496       44
                            1.65       51    2.81640625       45
    -2.55                   1.8        52        1.1761       46
9.9999999 99?               1.95       53   -0.60449375       47
                            2.1        54       -2.4464       48
    -2.85       21          2.25       55   -4.25849375       49
     -2.7       22          2.4        56       -5.9375       50
    -2.55       23          2.55       57   -7.36799375       51
     -2.4       24          2.7        58       -8.4224       52
    -2.25       25          2.85       59   -8.96099375       53
     -2.1       26                              -8.8319       54
    -1.95       27    7.99500625       21   -7.87109375       55
     -1.8       28        1.8241       22       -5.9024       56
    -1.65       29   -2.73749375       23   -2.73749375       57
     -1.5       30       -5.9024       24        1.8241       58
    -1.35       31   -7.87109375       25    7.99500625       59
     -1.2       32       -8.8319       26
    -1.05       33   -8.96099375       27
```

calculator simply indicates the lowest root in approximate fashion and then rapidly prints out the tables of values of x and $P(x)$ at the assigned values of a and b (see listing 2).

All that remains is to use these values contained in registers R_{21} to R_{59} for the plot by continuing with the known steps as follows:

6. In groups 1 and 2 read the card of the program for the function curve.
7. Initialize with key A.
8. With the keys punch in −9 B then 8 B to enter the extremes which are obviously appropriate here.
9. Depress key C which delivers the six ideal strips after this mathematical "zooming" as can be seen from looking at the curve in detail (see figure 1).

Above all, the question is one of knowing if this plot is technically satisfactory.

For verification purposes, see if the coordinates of the minimums found by the calculation (±2, −9) and the coordinates measured on the plot are consistent. More precisely, determine the abscissa of the minimums with an ordinate of −9. From the small median triangular sign marking the 0 abscissa on the base line, you can easily count ±13 intervals each having a value of 0.15, the increment of x. This gives $\pm 13 \times 0.15 = \pm 1.95$. This abscissa is very close to the value calculated (±2), and it can be said that the plot is extremely accurate.

As for the points of inflection, their ordinate is found to be —1.888... for $P(x)$ evaluated from the roots of $P''(x) = 0$, in other words abscissas of ±1.154700. The points of inflection whose abscissa is ±1.15 in accordance with the calculation fall slightly before the eighth point on the base line at the abscissa ($8 \times 0.15 = 1.20$). This is also very close to the value calculated. These are the points where the curve crosses its tangent.

The zero ordinate can easily be deduced from a simple rule. Given that the difference between minimum and maximum is $9 + 8 = 17$ in absolute value and there are $4 \times 20 + 17 = 97$ elementary intervals between these points, each has a value of 0.175. From this the axis of the abscissas is at $9/0.175 = 51$ intervals from the minimum of the curve.

From the table of $P(x)$ it can be seen that the curve cancels between registers R_{34} and R_{33}, R_{46} and R_{47}, and that this effectively corresponds to the interval 6-7 of the base line. Without providing the precision of a professional plotter, the reproduction obtained is thus of suitable quality given the means employed.

Conclusion

When a procedure is used for a rather long calculation that requires only three keyboard operations:

- initialization by key A
- data entry by key B or B′
- complete execution by key C

the drawbacks of the relative slowness of calculation are considerably reduced.

The TI-59 cannot execute its program with great speed. However, most users can tolerate a delay of a few minutes with no hardship. Some will appreciate the option of allowing users to disable automatic operation to follow their own inspiration. ■

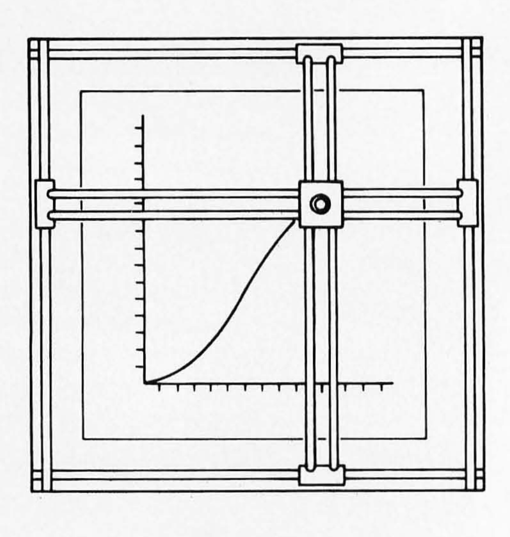
The Plot Continues

Leslie B Walter
72 Central St
Farmington NH 03835

I had a dream the other night. A wondrous vision: I built an inexpensive, simple plotter and it worked. I remember that just before retiring, I was reading the March 1977 BYTE, specifically the article on building a plotter using model aircraft servomotors ("Give Your Micro Some Muscles," page 9).

The servomotor idea sounded great at first, but is quite complicated to run. For one thing, the plotting routine must constantly send out carefully timed pulses. Either that or you need a set of programmable clocks. Second, you must have a circuit that indicates when the plotter is finished with the current line segment or you would be plotting the next line before the first line is finished (unless you want to wait out the worst case every time). Third, there is that trigonometric routine. I don't even want to think about that. Fourth, there is the problem of wobble. With arms long enough to give a decent sized plotting area, the slightest bump or small snag on the paper and your beautiful plot begins to look like a Los Angeles seismograph record. Arms rigid enough to avoid this problem would be extremely difficult to build. There is also the problem of play. At the end of 10-inch arms, a small amount of play at the servomotors would be greatly magnified, possibly enough to miss the desired point by a fair margin.

I propose the following alternative design approach. The idea isn't perfect, but I think it will work.



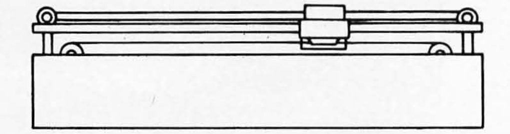


Figure 1: A sketch of the complete plotter mechanism.

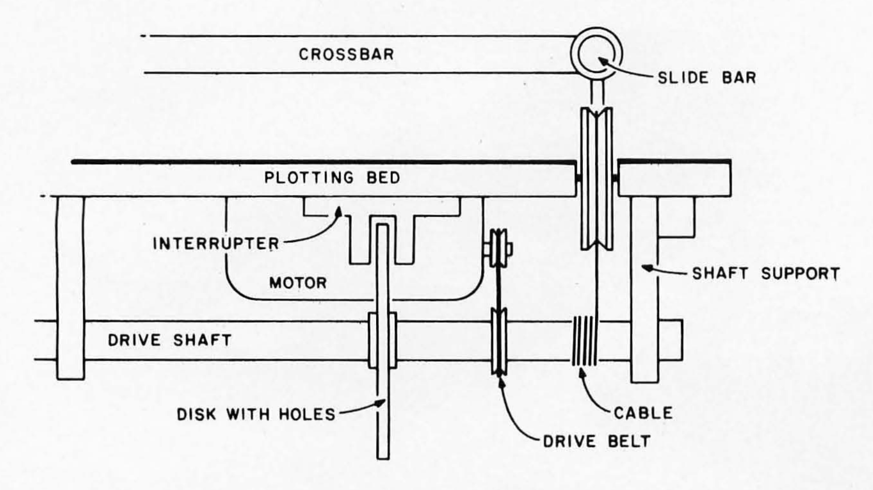


Figure 2: Cutaway showing details of drive mechanism. The motor drives the shaft, turning the disk. The interrupter sends a pulse to the controller each time a hole passes through it. A cable wrapped around the shaft comes up through the plotting bed and pulls the crossbar along the slide. There should be a cable at each end of the crossbar.

Mechanical Description

The basis for the plotter (and the hardest part to build) is the crossbars (figures 1 and 2). These are two sets of perpendicular bars that slide on long rails set at the edge of the plotting bed. The pen mount with its solenoid sits on the intersection of the bars. It slides along in a fashion similar to the crossbars and their rails. By moving the crossbars to the proper X,Y coordinates the pen moves with the intersection to the desired point.

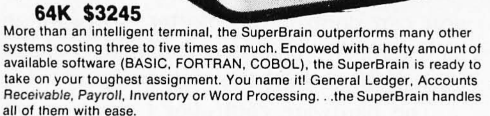
The bars are moved by cables wrapped around a drive shaft. Rotating the shaft in one direction moves the bar up (or down). The other bar is moved by a similar arrangement, right or left. In order to keep track of where the bars are, each drive shaft has a disk mounted on the end with holes evenly spaced around it. As the disk rotates

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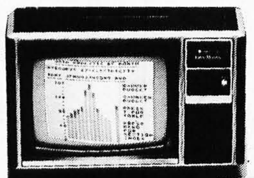
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with the shaft, the holes pass through an optical interrupter (a U-shaped device with a light source on one side and a phototransistor on the other). Each time a hole passes through the interrupter, a pulse passes to the control circuit, driving a counter up or down depending on the direction it's turning. By comparing the counter, which contains the current position of the bar, with the desired destination point, the control circuits can move the bar in the proper direction.

One small problem lies in the hardware department. The motors which drive the crossbars must be able to stop fairly fast, at least before the next hole comes up on the disk. If not, the plotter would signal the computer that it is finished even though the motors would have to reverse themselves to return to the original point. If you are using motors that are geared down (ie: the motors are spinning fast, but the shaft is turning slowly) then this problem tends to disappear. The disadvantage to geared down motors is time, of course. The more gear reduction that is used, the longer it takes to draw a *line* segment, and the longer your processor is sitting idle. The ideal motor is one that turns the shaft as fast as the pen and paper can tolerate and which can stop quickly.

Controlling the Plotter

From here there are two ways in which you can control the plotter: software and hardware. My choice is hardware, although both methods have their advantages.

The hardware controller I came up with (figure 3) is simple. Set up three input/

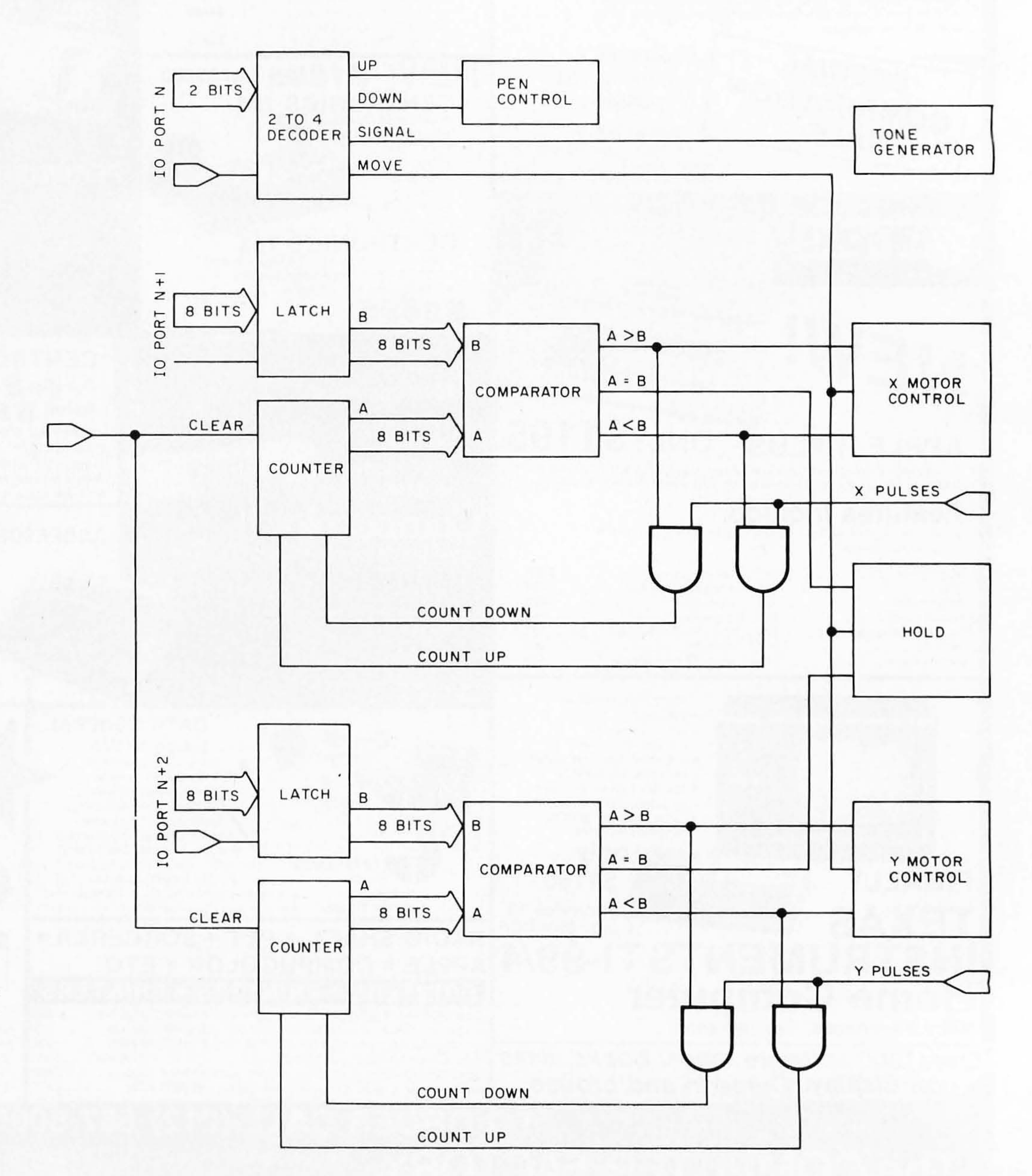
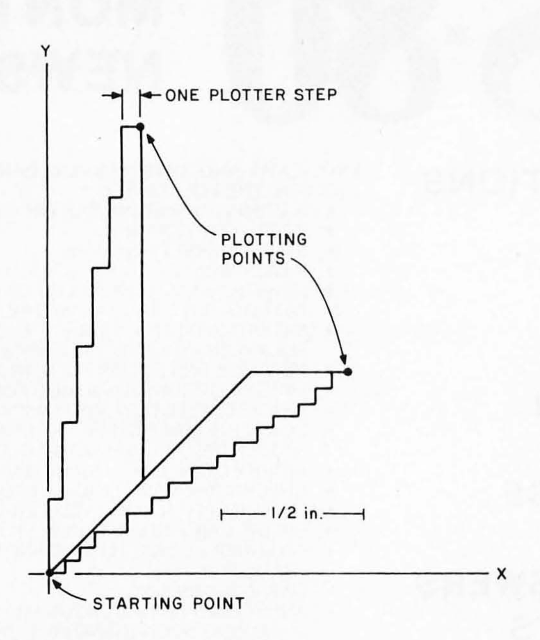


Figure 3: A block diagram of a hardware plotter controller.

Figure 4: A sketch of the 45° syndrome. The stepped lines indicate the type of line drawn by a software driven plotter. The lines with the single angle are the type drawn by the hardware controller. If the line segment to be drawn is less than a few plotter steps long, the difference is negligible.



output (I/O) ports: one for commands and one each for the X and Y coordinates.

The command port accepts four commands: pen up, pen down, signal and move. The two pen commands are self-explanatory; the signal command generates an audible tone. This is an option I included for signalling the end of a plot or calling attention to a particular point in the plotting process.

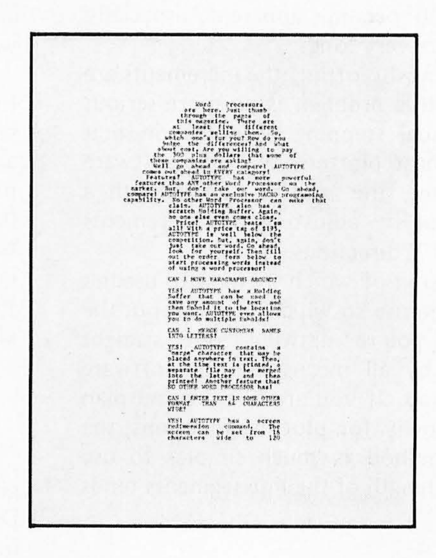
The move command starts the motor circuits (otherwise they would start moving the plotter before both coordinates were in) and also generates a hold signal for the processor until the line segment is finished. When the move command is received, the motors drive the crossbars until the counters, which hold the current plotting position, match up with the eight-bit latches which contain the position that the plotter is to move to. When the coordinates match, the hold line is dropped, allowing the computer to output the next command.

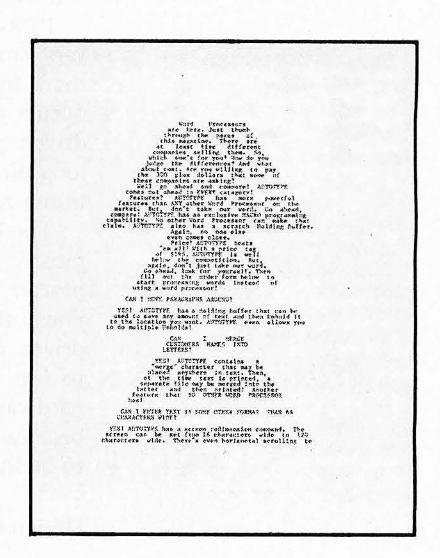
The comparator circuits are also used to determine whether the pulses coming from the interrupters are used to drive the counters up or down.

The only other circuit needed is an initialization circuit that drives the pen to location (0,0) and clears the counters. This is used to synchronize the counters and pen when the plotter is first turned on.

As to the circuits which actually drive the motors and pen solenoid, these depend on the components themselves. If you wish to drive the plotter directly by software, the two coordinate I/O ports are used to read the current location of the pen. A software routine then decides how to move the crossbars, one step at a time, to get to the desired point. However, this requires more commands for the plotter, such as X up, X down, Y up, Y down.

With this hardware method you run into what I call the 45° syndrome. Since the motors turn at about the same speed, the pen will tend to move at an angle which is a multiple of 45°. For example, if the pen has farther to go in the X direction, the pen will reach the proper Y coordinate first, giving a line with two segments (figure 4). If the line you wish to draw is a multiple of 45°, drawing axes and such, then this presents no problem, but with lines at other





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angles it will become apparent, especially if the lines are very long.

If, as in most plotting, the increments are very small, this problem is no more serious than the usual stepping phenomenon that occurs on most plotters. With the software driven plotter, the routine can smooth a long line out by adjusting the increments in the X and Y directions.

The decision of which method to use lies mostly in the use to which you will put the plotter. If you're drawing long straight lines, then by all means use the software driven method. If you are like me and plan to use it mostly for plotting functions, the hardware method is much simpler to use because the length of the line segments tends to be short.

Design Details

In designing a plotter for your own use, there are three factors to keep in mind. They are the desired resolution, the size of the plotting area and the number of bits used for the coordinates. Determining any two of these factors automatically sets the third.

For instance, in my design I used a resolution of 0.05 inches (0.13 cm) and an 8-bit coordinate system. This gave me a plotting area of 12.8 inches (33 cm) square. That was big enough for me.

The drive shaft is what causes problems. In order to have an exactly evenly spaced set of holes on the disk, you have to have a shaft with a circumference that is a multiple of the resolution, in this case 0.05 inches (0.13 cm). This is not easy. Short of going to a machine shop and having them turn out special drive shafts, I decided to search for a standard diameter that would come close. One half inch works out fairly well.

With 31 holes in the disk, the formula:

$$RES = (\pi \times DIAM)/H$$

gives the true resolution. Here, π is 3.1415, DIAM is the drive shaft diameter (0.5 inches), H is the number of holes and RES is the true resolution, in this case 0.05067 inches, which was close enough to 0.05 to suit me.

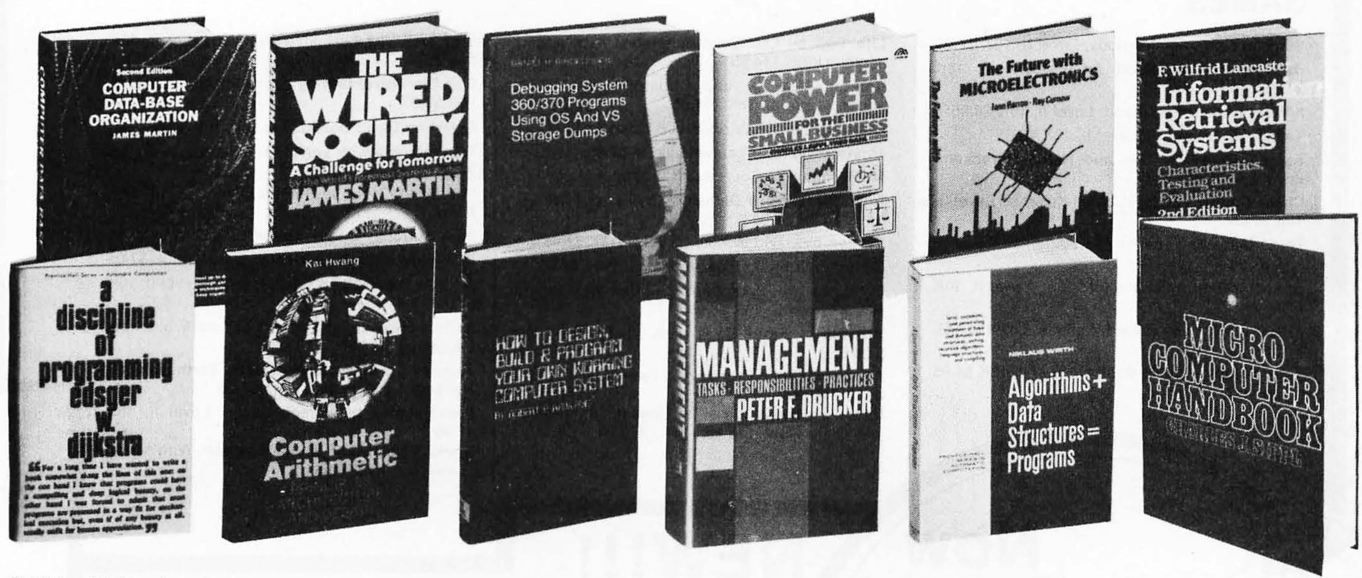
What this formula means is that the holes divide the circumference of the drive shaft into 31 segments, each one 0.05067 inches long. Thus as the cable comes off the shaft, driving it one hole means that the crossbar will move 0.05067 inches.

The only other critical parts are the crossbar slides since the crossbars must glide smoothly.■

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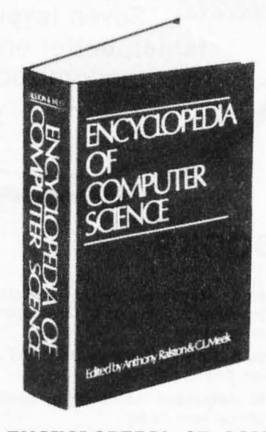
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Technical Forum

Aids to the Direct Reception of Weather Satellite Photographs

William D Johnston, 1808 Pomona Dr, Las Cruces NM 88001

A recent note in "BYTE's Bits" (June 1979 BYTE, page 225) brought to the attention of BYTE readers the prospect of direct reception of weather satellite photographs by amateurs using home-built equipment. The purpose of this brief article is to expand on that note, and to direct the interested reader to a number of existing resources.

Applications of the home computer in this field are many and varied. They include such projects as orbital predictions, antenna tracking calculations, signal error analysis, generation of map overlays, and weather system modeling, to name just a few. Most of the mathematical calculations involved are quite simple, requiring the use of nothing more difficult than high school trigonometry. A computer enthusiast can derive a great deal of personal satisfaction from writing software to arrive at the correct solutions. Those who are hardware oriented will want to go a step further and use their computers to drive a tracking antenna in real time.

The 1968 report by Vermillion (NASA SP-5079) mentioned in BYTE's Bits was not the first to appear on the subject. A comprehensive article on building a home receiving station appeared in *QST* magazine as far back as 1965. Vermillion himself put out a number of other excellent NASA reports since the 1968 document, including SP-5080 and TN D-7994. *Scientific American* carried a construction article based on a design similar to the 1965 *QST* equipment.

The great majority of technical literature on the subject, however, has appeared in the various American and British amateur radio magazines over the past five or six years. A review of the annual indices (usually appearing in the December issues) of *Ham Radio, QST, Radio Communication,* and *Wireless World* will reveal a wealth of information. These articles are indexed under "Satellites," "Weather Satellites," "OSCAR," and "Facsimile." The subject matter runs the gamut from construction details for homebrew state-of-the-art receivers and recorders, to surplus equipment conversions, to computer software for orbital calculations and antenna tracking.

An excellent book on the subject has been written for amateurs by Ralph Taggart. Mr Taggart is the author of

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   5    178    3   3093
   6    180    7   2706
   7    183   12   2327
   8    186   18   1961
   9    192   26   1618
  10    202   37   1319
  11    223   49   1102
  12    262   55   1022
  13    299   48   1108
  14    318   36   1328
  15    327   26   1628
  16    333   18   1971
  17    336   12   2336
  18    339    7   2715
  19    341    3   3100
  20    342   -1   3488

EQ CROSSING AT  68 DEGS
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MINS     DG   DG     KM
   4    179    0   3479
   5    180    3   3092
   6    182    7   2708
   7    185   12   2333
   8    190   18   1971
   9    196   26   1636
  10    207   35   1347
  11    228   46   1141
  12    264   51   1070
  13    297   45   1158
  14    315   34   1375
  15    325   25   1670
  16    331   18   2008
  17    335   12   2370
  18    338    7   2745
  19    340    3   3127
  20    342   -1   3513
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Listing 1: *A small portion of a typical satellite tracking printout generated on a home computer. The data can be calculated in real time, or a perpetual-prediction printout (about fifty pages long) can be prepared in advance. All calculations are based on the exact location of the ground station that is to use the printout.*

many of the articles that have appeared in the amateur radio magazines, including a very good introductory treatise for beginners.

BYTE has published material which is directly applicable to the subject. This was related to computer generation of map overlays for satellite photos. It is a very handy capability to have on occasions when your received pictures show nothing but cloud cover and you need a system of reference (see my article series "Computer Generated Maps," May 1979 BYTE, page 10; June 1979 BYTE, page 100).

Those who are concerned about the cost and complexity of such a project need not worry. It is entirely possible to assemble a station capable of receiving high-resolution photos (both visible light and infrared images) with an outlay of less than $100. Excellent quality picture recorders, capable of recording images up to 19 inches (48 cm) square, are available on the surplus market for as little as $50. Recorders that produce pictures about 4 by 6 inches (10 by 15 cm) can be found for as little as $10. Advertisements in the amateur radio magazines and visits to ham radio swap meets provide the best leads to equipment buys. Many of the previously mentioned articles even show you how to build a recorder from scratch,

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GROUND STATION AT: NEW HAMPSHIRE, PETERBOROUGH 42 53N 71 57W

SYNCHRONOUS SATELLITE LONG. DEG	AZ DEG	EL DEG	RANGE KM	SYNCHRONOUS SATELLITE LONG. DEG	AZ DEG	EL DEG	RANGE KM	SYNCHRONOUS SATELLITE LONG. DEG	AZ DEG	EL DEG	RANGE KM	SYNCHRONOUS SATELLITE LONG. DEG	AZ DEG	EL DEG	RANGE KM
0 W	103	4	41191												
1 W	103	5	41112	46 W	144	34	38273	91 W	207	37	38035	136 W	252	10	40576
2 W	104	6	41033	47 W	146	34	38234	92 W	208	37	38066	137 W	252	9	40653
3 W	105	7	40955	48 W	147	35	38197	93 W	209	36	38097	138 W	253	9	40729
4 W	105	7	40876	49 W	148	35	38161	94 W	211	36	38130	139 W	254	8	40807
5 W	106	8	40799	50 W	149	36	38127	95 W	212	35	38165	140 W	255	7	40884
6 W	107	9	40722	51 W	151	36	38094	96 W	213	35	38201	141 W	255	7	40962
7 W	108	10	40645	52 W	152	37	38063	97 W	214	34	38236	142 W	256	6	41041
8 W	108	10	40569	53 W	153	37	38032	98 W	216	34	38277	143 W	257	5	41120
9 W	109	11	40493	54 W	155	37	38004	99 W	217	34	38317	144 W	258	4	41199
10 W	110	12	40418	55 W	156	38	37977	100 W	218	33	38358	145 W	258	4	41278
11 W	111	12	40343	56 W	157	38	37951	101 W	219	33	38401	146 W	259	3	41358
12 W	111	13	40269	57 W	159	38	37927	102 W	220	32	38445	147 W	260	2	41438
13 W	112	14	40195	58 W	160	39	37904	103 W	221	31	38491	148 W	260	1	41518
14 W	113	14	40122	59 W	161	39	37883	104 W	223	31	38537	149 W	261	1	41598
15 W	114	15	40050	60 W	163	39	37864	105 W	224	30	38585	150 W	262	0	41679
16 W	115	16	39979	61 W	164	39	37846	106 W	225	30	38634	151 W	***	**	*****
17 W	116	17	39908	62 W	166	40	37829	107 W	226	29	38685	152 W	***	**	*****
18 W	116	17	39838	63 W	167	40	37815	108 W	227	29	38736	153 W	***	**	*****
19 W	117	18	39769	64 W	168	40	37801	109 W	228	28	38789	154 W	***	**	*****
20 W	118	19	39700	65 W	170	40	37789	110 W	229	28	38843	155 W	***	**	*****
21 W	119	19	39632	66 W	171	40	37779	111 W	230	27	38896	156 W	***	**	*****
22 W	120	20	39565	67 W	173	40	37771	112 W	231	26	38954	157 W	***	**	*****
23 W	121	21	39499	68 W	174	40	37763	113 W	232	26	39011	158 W	***	**	*****
24 W	122	21	39434	69 W	176	40	37758	114 W	233	25	39070	159 W	***	**	*****
25 W	122	22	39370	70 W	177	40	37754	115 W	234	24	39129	160 W	***	**	*****
26 W	123	23	39307	71 W	179	41	37752	116 W	235	24	39189	161 W	***	**	*****
27 W	124	23	39245	72 W	180	41	37751	117 W	236	23	39251	162 W	***	**	*****
28 W	125	24	39183	73 W	182	41	37752	118 W	237	23	39313	163 W	***	**	*****
29 W	126	25	39123	74 W	183	40	37754	119 W	238	22	39377	164 W	***	**	*****
30 W	127	25	39064	75 W	184	40	37758	120 W	239	21	39441	165 W	***	**	*****
31 W	128	26	39006	76 W	186	40	37764	121 W	239	21	39506	166 W	***	**	*****
32 W	129	26	38948	77 W	187	40	37771	122 W	240	20	39572	167 W	***	**	*****
33 W	130	27	38892	78 W	189	40	37780	123 W	241	19	39639	168 W	***	**	*****
34 W	131	28	38837	79 W	190	40	37790	124 W	242	19	39707	169 W	***	**	*****
35 W	132	28	38784	80 W	192	40	37802	125 W	243	18	39775	170 W	***	**	*****
36 W	133	29	38731	81 W	193	40	37816	126 W	244	17	39845	171 W	***	**	*****
37 W	134	29	38679	82 W	195	39	37831	127 W	245	16	39915	172 W	***	**	*****
38 W	135	30	38629	83 W	196	39	37848	128 W	245	16	39986	173 W	***	**	*****
39 W	136	30	38580	84 W	197	39	37866	129 W	246	15	40057	174 W	***	**	*****
40 W	137	31	38532	85 W	199	39	37885	130 W	247	14	40130	175 W	***	**	*****
41 W	139	32	38486	86 W	200	39	37907	131 W	248	14	40203	176 W	***	**	*****
42 W	140	32	38441	87 W	202	38	37929	132 W	249	13	40276	177 W	***	**	*****
43 W	141	33	38397	88 W	203	38	37954	133 W	249	12	40350	178 W	***	**	*****
44 W	142	33	38354	89 W	204	38	37979	134 W	250	12	40425	179 W	***	**	*****
45 W	143	34	38313	90 W	206	37	38007	135 W	251	11	40500	180 W	***	**	*****

*** MEANS THAT A GEOSYNCHRONOUS SATELLITE AT THE GIVEN POSITION IS NOT VISIBLE FROM THIS GROUND STATION.

Listing 2: *Part of a geosynchronous satellite antenna-pointing chart created on a home computer. Knowing the station longitude of a particular satellite, one simply refers to that entry in the chart to find the antenna-pointing angles. The illustrated example was prepared for a ground station located in Peterborough NH, site of the offices of BYTE Publications.*

using simple materials (eg: a kitchen rolling pin for a recording drum!), if you cannot find or do not want to buy a surplus recorder.

The necessary radio receiving equipment is also reasonably simple. If you already own a general coverage receiver, a converter can be built for as little as four or five dollars. In fact, many public-service band radios and scanners can receive the satellites directly (on 137.5 MHz), and all you need to add is an outdoor antenna.

Satellite tracking should be a snap for the average computer enthusiast. The published literature includes many articles on satellite tracking software. The only additional data you need is the time and longitude of the equator crossing of an occasional reference orbit (once every few weeks or so). Reference orbit information is transmitted daily via teletypewriter to most National Weather Service (NWS) offices on the TBUS circuit. The National Weather Service also carries the information on their high-frequency radio teletypwriter (RTTY) circuits. The American Radio Relay League station W1AW transmits the same information by both voice and radio teletypewriter. See any recent issue of *QST* for the W1AW transmission schedule. It is also possible to have your name put on a mailing list maintained by the National Environmental Satellite Service, and receive this information by mail on a monthly basis.

Some weather satellites are in geosynchronous orbits; that is, their periods of revolution are the same as the rotational period of the earth (ie: 24 hours). Consequently, they remain stationary with respect to the earth's surface. This makes life really simple because you do not have to track them. It is only necessary to compute the antenna pointing angles once for each satellite. A recent article about locating geosynchronous satellites in *QST* gives the procedure for doing this on either a pocket calculator or a home computer.

Listings 1 and 2 show portions of the output from typical home-computer programs for polar orbiting and geosynchronous satellites, respectively. The programs that produced them are based on articles that have appeared in amateur radio magazines, and they require just a few seconds to execute.

As you can see, there are quite a few areas of opportunity for home computer projects in this exciting field. It is intriguing to receive real-time weather satellite photos right in your own home and to try to outguess the

weatherman! You can even use your computer to maintain weather records over long periods of time to aid in your forecasting.

I do not personally have additional advice to offer on construction details or equipment recommendations, other than to refer the reader to the many excellent articles already in print. I can, however, provide some assistance with tracking data. As an extension of a service I provide to amateur radio operators to assist in tracking the OSCAR communications satellites, I also provide perpetual orbital-prediction printouts for the current primary polar orbiting weather satellite, TIROS-N. (I have discontinued the printouts for all of the earlier weather satellites, but the service will be extended to include NOAA-6, which was launched in June 1979.) A printout showing antenna pointing data to all geosynchronous satellite locations, in one-degree increments, is also available.

All printouts are computed based on the exact station location, and can be used directly for tracking or as a check on the accuracy of programs you develop on your own. There is a nominal charge for the printouts ($5.00 for the TIROS-N printout, and $1.00 for the geosynchronous satellite printout) to help defray the cost of postage and materials. If you would like additional information about the printouts, be sure to enclose a *self-addressed, stamped envelope* with your letter. ■

REFERENCES

1. Anderson, Wendell G, "Amateur Reception of Weather Satellite Picture Transmissions," *QST*, November 1965, page 11.
2. Johnston, William D, "Computer Generated Maps," *BYTE*, May 1979, page 10 and June 1979, page 100.
3. Johnston, William D, "Locating Geosynchronous Satellites," *QST*, March 1978, page 23.
4. Ruperto, Eugene F, "Weather Satellite Pictures Are Picked Up in the Home," *Scientific American*, January 1974, page 114.
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6. Taggart, Ralph E, *Weather Satellite Handbook*, 1976, 73 Inc.

An Improved Maze Program

David Lyons, 77 Elizabeth St S, Brampton Ontario, CANADA L6Y 1R3

I enjoyed "My Computer Runs Mazes," by David E Stanfield in the June 1979 BYTE, page 86. I agree that the form of the listing provided is easy to enter, but it could be difficult to modify the program for other systems. Therefore, I have compiled the following information which might help.

The maze matrix will not print properly on terminals with line lengths other than thirty-two characters or

Listing 1: *Adding carriage return and line feed to maze display output.*

Hexadecimal Address	Hexadecimal Code	Instruction Mnemonic	Operand
0283	26 EB	BNE	$0270
0285	BD 02 5F	JSR	CRLF
0288	01	NOP	
0289	01	NOP	

without screen wraparound, since screen wraparound is relied upon for the carriage return and line feed after each row of alternating X and space characters. These missing characters can be added by a modification to the appropriate printing routine, as in listing 1.

Cursor-right and cursor-up characters do not always seem to be standard. The locations in which they occur are listed in table 1, if you need to alter them. Contrary to what is implied in the listing in the original article, the maze-running program is contained in two sections of memory, one from hexadecimal 003D to 0060, and the other from hexadecimal 0100 to 0784. Also, the display memory is located between hexadecimal 0800 and 09FF.

Now I shall suggest some possible enhancements. Provisions are made to open up corridors and set the goal, but not to replace a wall or remove the food except by redrawing the entire maze. By adding the patch in listing 2, the command table can be extended to allow the setting of an X at the current cursor location by pressing the X key.

If the goal is not accessible in the maze, the same branches can be searched repeatedly before the search ends. This seems due to the search strategy of eliminating only the end location of a branch each time a dead-end is reached, even though the *entire* branch back to the nearest node could be eliminated when backtracking is necessary. The strategy can be modified so that dead-end paths are searched only once by changing four conditional branch (BEQ) instructions as shown in table 2.

Listing 2: *Command table extension.*

Hexadecimal Address	Hexadecimal Code	Label	Instruction Mnemonic	Operand
02B3	BD 07 85		JSR	PATCH
0785	81 58	PATCH	CMP A	#'X
0787	26 08		BNE	NFOUND
078A	BD 02 DD		JSR	BACKSPACE
078D	86 58		LDA A	#'X
078F	A7 00		STA A	0,X
0791	39		RTS	
0792	7E 02 D3	NFOUND	JMP	RESTORECHAR

Move-Right Character	Move-Up Character
031B	03AD
0498	056F
0520	069C
0686	

Table 1: *Hexadecimal addresses of instructions using cursor-control characters.*

Hexadecimal Location	Hexadecimal Branch Value
05C8	42
05FB	E9
0624	27
0643	E9

Table 2: *Search strategy modification. Deposit the indicated branch values into the corresponding memory locations.*

This change also has the added advantage of allowing the search to terminate on its own. You do not have to reset the computer if a loop is encountered in a maze. I hope that these comments will help others to enjoy this program. ■

Alpha Lock for Your ASCII Keyboard

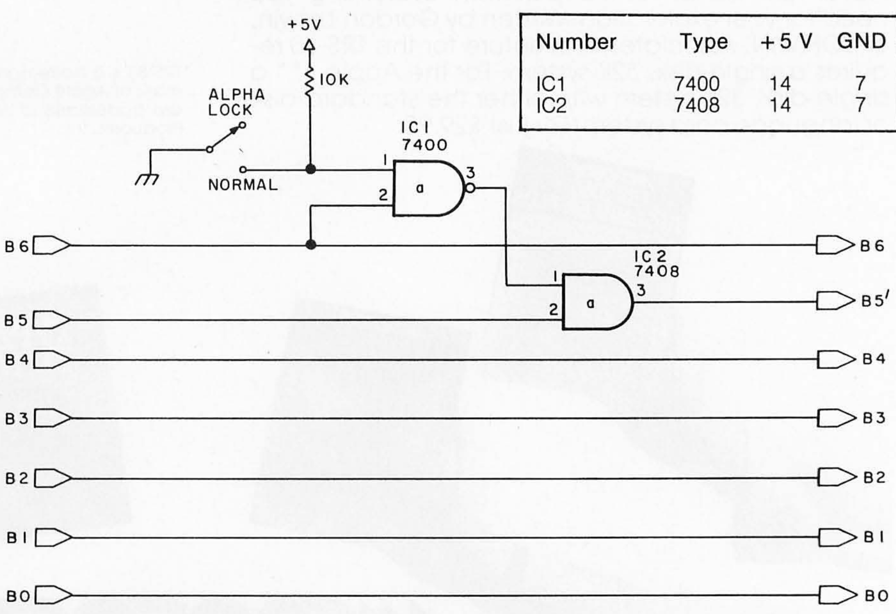
Terry Conboy
1231 Crestview Dr
San Carlos CA 94070

There are times when you need to hold the output of your keyboard in the uppercase mode for all alphabetic characters. A great deal of software is designed to accept only uppercase alphabetic American Standard Code for Information Interchange (ASCII) characters. The circuit given here is designed to be placed between the transistor-transistor logic (TTL) parallel output of the keyboard and the parallel input port on the computer (or the input to the parallel-to-serial converter in a serial data arrangement). The programmer will then be able to reduce the beautifully designed 128-character set to a 102-character set.

A quick glance at a table of ASCII characters will show that the alphabetic characters are easy to recognize. (Such a table appeared in "Complete ASCII" by David M Ciemiewicz in the February 1978 BYTE, page 19.) They all have a 1 in bit 6 (the most significant data bit not considering the parity bit). Lowercase characters have bit 5 equal to 1, and uppercase characters have bit 5 equal to 0. If the problem was as simple as this, the circuit shown in figure 1 would do the trick. (I was inspired to

ASCII Character	Binary 6543210	Bits 6,4,3 Octal	Bits 2,1,0 Octal
@	1000000	4	0
[	1011011	7	3
\	1011100	7	4
]	1011101	7	5
^	1011110	7	6
_	1011111	7	7
`	1100000	4	0
{	1111011	7	3
¦	1111100	7	4
}	1111101	7	5
~	1111110	7	6
Delete	1111111	7	7

Table 1: *The 12 ASCII characters with a binary representation having bit 6 (the most significant data bit, not considering the parity bit) equal to 1 that should not be shifted by the uppercase alpha-lock function.*

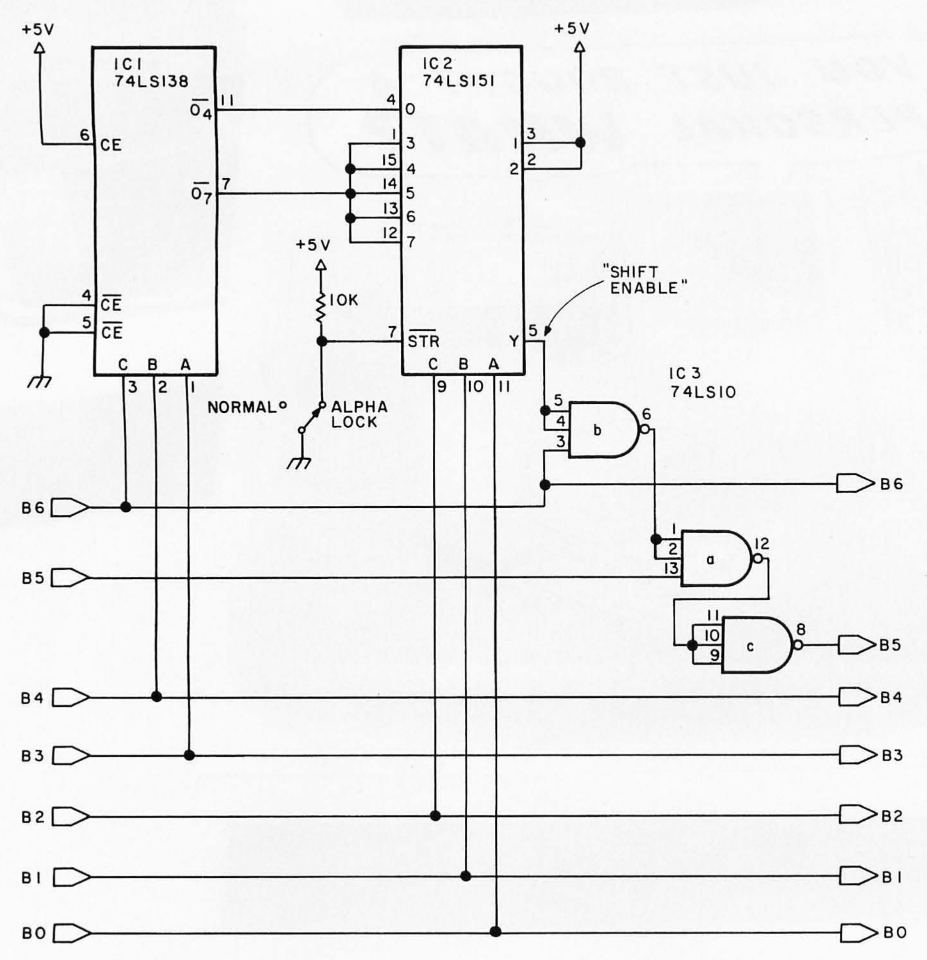


Number	Type	+5 V	GND
IC1	7400	14	7
IC2	7408	14	7

Figure 1: *A simple circuit to provide alphabetic uppercase lock. It causes the undesired shift of 6 punctuation and control codes in addition to the alphabetic characters.*

About the Author

Terry Conboy is employed as a staff engineer for microwave telecommunications development at GTE Lenkurt in San Carlos CA. Interested in computers and digital communication, he is an Extra class amateur radio operator and has published articles in several ham radio magazines.



Number	Type	+5 V	GND
IC1	74LS138	16	8
IC2	74LS151	16	8
IC3	74LS10	14	7

Figure 2: *An alphabetic uppercase lock circuit which shifts only the 26 alphabetic characters when enabled by the switch.*

develop this circuit by an idea description "Recognize Uppercase Letters Only with a Simple 2-Gate Circuit," in *Electronic Design*, July 19 1977, page 106, written by Chacko Neroth.)

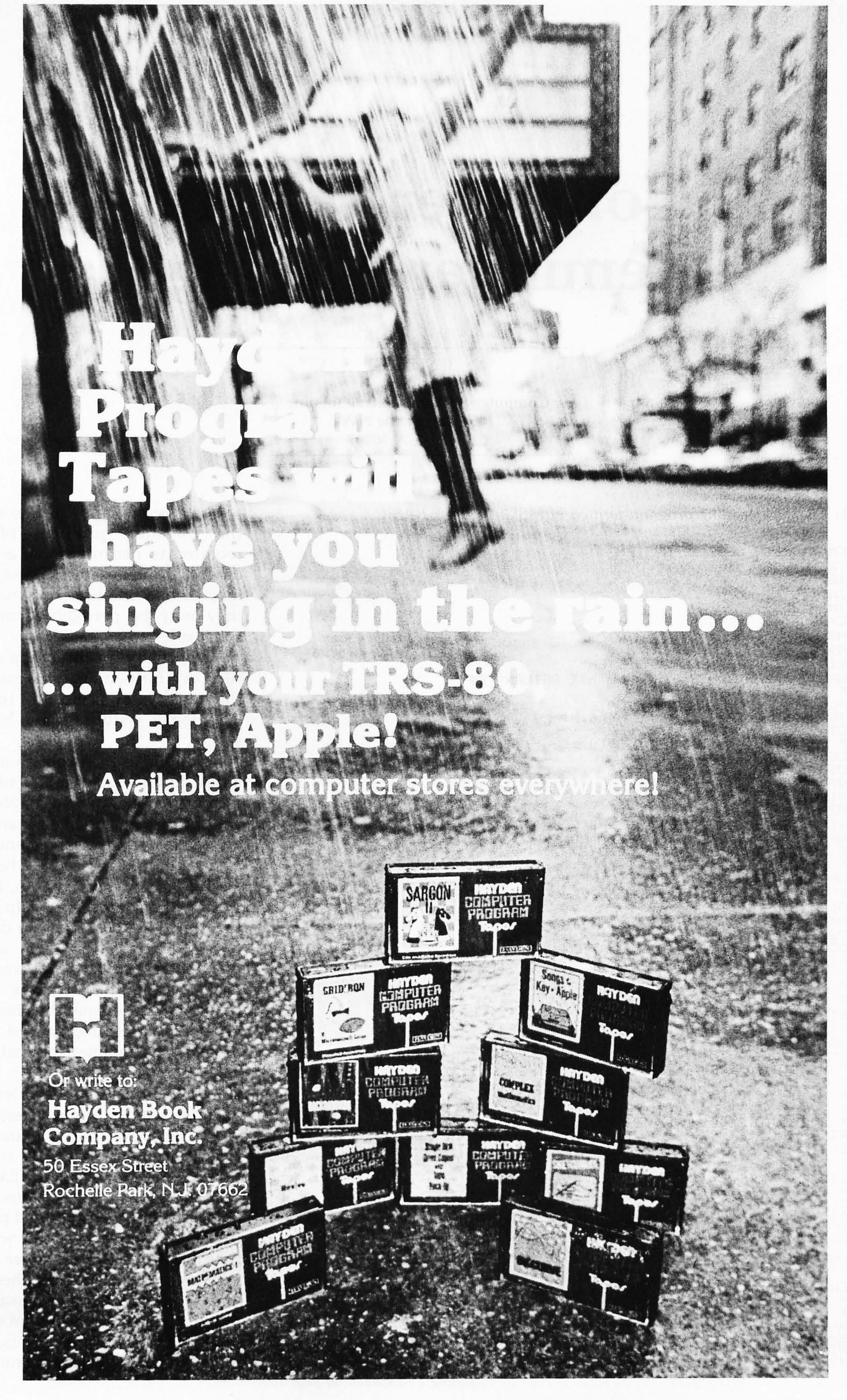
Of course there is a catch. There are 64 binary combinations in which bit 6 is 1, and only 52 of them are letters. The remaining combinations are punctuation marks, with the exception of the *delete* control code, as shown in table 1. If the keyboard omits these characters, the simple circuit of figure 1 will force bit 5 low when bit 6 is 1 and the circuit is enabled. However, if the keyboard does have these codes (and it probably has *delete*), remembering to unshift when necessary can be a headache.

To overcome this problem, it is necessary to detect the 12 nonalphabetic characters and inhibit the shift automatically. My first thought was to use a multitude of inverters and 8-input NAND gates (such as the system described by Steve Ciarcia in "Build a Keyboard Function Decoder," July 1978 BYTE, page 98), but there had to be a better way. Use of a programmable read-only memory would be nice, but it seemed like overkill and perhaps more expensive than necessary.

The solution turned out much simpler than I expected. By forming the octal equivalent of the group of bits 6, 4, and 3 and of the group of bits 2, 1, and 0, as shown in the last columns of the table, the user can see that by detecting the coincidence of these combinations, the desired shift enabling line can be obtained. The lucky combination of octal numbers allows the use of a 3-to-8-line decoder (74LS138) to unscramble the 3 most significant bits of interest and an 8-line multiplexer/data selector (74LS151) driven by the 3 least significant bits. By selecting the proper outputs from the decoder and data selector (those corresponding to the codes we wish to recognize), there can be case shifting at the proper times. The new circuit is shown in figure 2.

When the high-order bits are decoded, the corresponding output goes to 0. If the low-order bits select a 0 output from the decoder, the *shift enable* line will also go to 0. This allows bit 5 to pass through unchanged. If the alpha-lock function is not desired, allowing the active-low strobe input on the data selector to be pulled up to a 1 will force the shift enable line to 0 regardless of the data being sent.

The use of low-power Schottky TTL integrated circuits allows adding the alpha-lock function while typically increasing the load on the power supply by only 14 mA. The cost of the three integrated circuits will be easily under $2■



Circle 97 on inquiry card.

A Computer Generated Reminder Message

E M Pass
President
Computer Systems Consultants Inc
1454 Latta Lane NW
Conyers GA 30207

Listing 1: *The Tickler filing program written in MSI 14 K Disk BASIC.*

```
0100 REM TICKLER MESSAGE SYSTEM
0200 STRING= 68
0300 DIGITS= 0
0400 LINE= 0
0600 DIM A(255)
0700  Z=0
0800  A8=0
0900  A9=0
1000 PRINT "TICKLER MESSAGE SYSTEM"
1100 INPUT "INSERT DATA DISK AND HIT RETURN",Z$
1150 IF Z$="NEW" GOSUB 6460
1200 OPEN #10,"TICKLRX" FOR UPDATE
1300 FIELD #10,N1=2,N2=3,N3=6,N4=6,M$=68
1400 GET #10
1420 IF LEFT$(M$,7)="TICKLER" GOTO 1500
1440 CLOSE #10
1460 GOSUB 6460
1480 GOTO 1200
1500  A1=N3
1600  A2=N4
1620 PRINT "ENTER PRINT CONTROL AS FOLLOWS:"
1640 INPUT "  S=SELECTIVE,A=ALL,N=NONE,U=UPDATE ONLY ",Z$
1660 IF LEFT$(Z$,1)<"A" GOTO 1620
1680 IF LEFT$(Z$,1)>"U" GOTO 1620
1700 INPUT "ENTER CURRENT DATE (YYMMDD)",D9
1720 IF D9<>INT(D9) GOTO 1700
1740  D1=INT(D9/10000)
1760  D3=D9-D1*10000
1780  D2=INT(D3/100)
1800  D3=D3-D2*100
1860 IF ABS(D1-89)>11 GOTO 1700
1880 IF ABS(D2-6.5)>6 GOTO 1700
1900 IF ABS(D3-16)>15 GOTO 1700
1940 IF LEFT$(Z$,1)="N" GOTO 2320
1960 PRINT :PRINT:PRINT:PRINT
1980 IF A1<2 GOTO 2600
2000 FOR Q=2 TO A1
2020 GET #10
2040 IF N1<1 GOTO 2260
2060 IF LEFT$(Z$,1)="A" GOTO 2100
2080 IF N3>D9 GOTO 2300
2090 IF LEFT$(Z$,1)="U" GOTO 2190
2100 IF Z>0 GOTO 2140
2120 PRINT "ENTRY TYPE  DATE   UPDATE       MESSAGE":PRINT
2140  Z=Z+1
2145  I=68
2150  I=I-8
2154 IF I<20 GOTO 2160
2156 IF MID$(M$,I,8)="        " GOTO 2150
2160 PRINT " ";Q;TAB(8);N1;TAB(12);N3;" ";N4;TAB(32);"-";LEFT$(M$,I+8)
2180 IF LEFT$(Z$,1)="A" GOTO 2300
2190 IF N1=1 N1=0
2200 GOSUB 6000
2210 IF N1>1 N4=D9
2220 REWRITE #10
2240 IF N1>1 GOTO 2300
2260 IF A9<255 A9=A9+1
2280  A(A9)=Q
2300 NEXT Q
2310 PRINT :PRINT:PRINT:PRINT
2320 PRINT "ENTER ENTRY NUMBERS TO BE DELETED,";
```

Listing 1 continued on page 162

Most people and businesses share the common problem of being required to perform some actions at definite future dates. These actions may be of a one-time-only nature, or they may be periodic according to some rule.

The penalty for forgetting an event such as a birthday may be minor, but the penalty for neglecting to file an income-tax return may be more severe.

Solutions to the problem are numerous, and include the use of human memory alone, writing notes on a wall or desk calendar, or maintaining an ordered stack of notes and forms. The solution that I suggest here, called the Tickler filing system, involves the use of a computer to help perform this function. The program described here was written for a small maintenance service company which has, in addition to the normal requirements of small businesses, the necessity of keeping track of periodic preventative maintenance calls for its client companies.

The Tickler system enables a clerk to input a series of messages, each of which has a starting date and a code indicating the type of repetition desired for the message. Each time that the program is executed, it can check a file of messages and print and reschedule all messages for which the time limit has expired since the last printing. The clerk can then delete and add additional messages, as required. Since the program contains no features that are specific to the maintenance service company, it

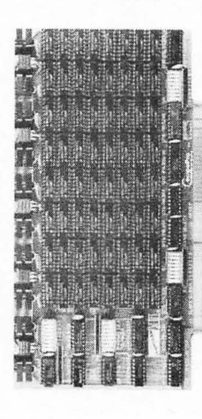
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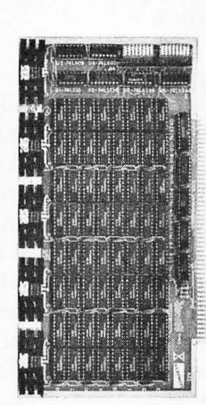
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16K Econoram XIIIA-16	S-100 (1)	$329	$419	$519
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A sample series of executions of the program appears in this article. The program provides prompts for the user after the file has been established. The user must enter NEW to establish the file. The ability to enter messages, message types, and starting dates should provide sufficient flexibility for virtually any simple application.

Program Details

The program in listing 1 was written using a SwTPC 6800 running the MSI 14K Disk BASIC interpreter level 1.3. The hardware includes 32 K bytes of main memory, one MSI floppy disk drive, and one low-speed (thirty character per second) printing terminal. The interpreter and this program require about 24 K bytes of memory. Since it uses random access techniques, adapting the program to a cassette tape system would be difficult. Implementing it on another disk system or on a timesharing system should not be difficult.

A flowchart of the major portion of the system appears as figure 1.

Initialization

Line 200 of listing 1 sets the string length to 68 bytes. For those with SwTPC 8 K BASIC, this statement may be replaced with POKE (62, 68). Line 300 sets up the output routine to print numeric values with a floating, not fixed, decimal point. Line 400 causes the output routine to ignore right margin considerations on output.

Line 600 allocates an area of 255 variables to point to those records that have been deleted and may be reused. Line 1100 causes the computer to wait until the clerk indicates that the proper disk has been mounted, since the data disk is kept apart from the program disk. Line 1150 checks for the entry of the word NEW, which indicates that the data file does not yet exist and is to be constructed.

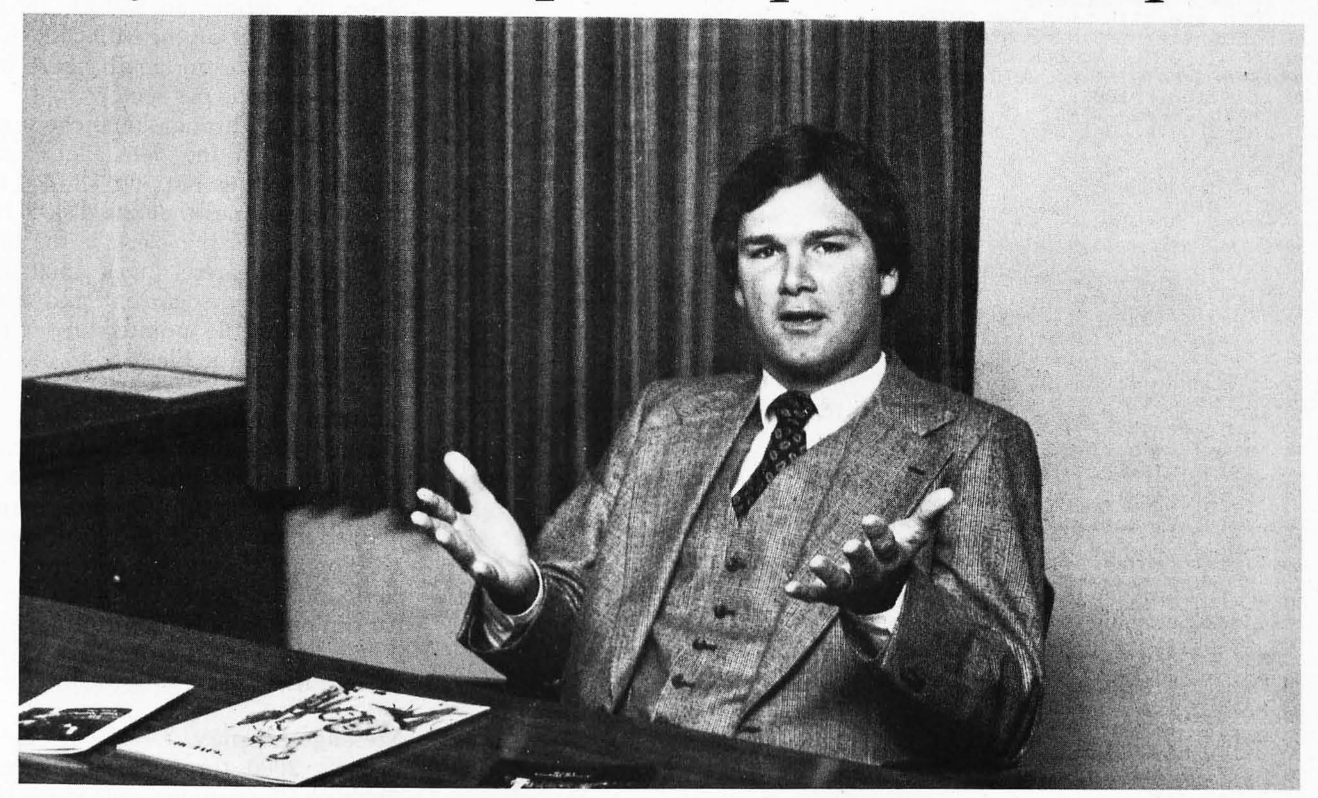
Line 1200 opens the data file in update mode; the MSI BASIC interpreter allows opening data files in Input, Output and Update modes. Line 1300 defines the format of the

Listing 1 continued:

```
2340 INPUT " FOLLOWED BY ZERO",Q
2380 IF ABS(Q)<>INT(Q) GOTO 2320
2400 IF Q>A1 GOTO 2320
2420 IF Q<1 GOTO 2600
2430 IF Q=1 GOTO 2320
2440 SET #10=Q
2460 GET #10
2480 IF N1<1 GOTO 2320
2500  N1=0
2520 IF A9<255 A9=A9+1
2540  A(A9)=Q
2560 REWRITE #10
2570 PRINT " ";Q;" DELETED"
2580 GOTO 2320
2600 INPUT "ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)",M1
2620 IF ABS(M1)<>INT(M1) GOTO 2600
2640 IF M1=0 GOTO 9000
2660 IF M1<10 GOTO 3040
2700 PRINT
2720 PRINT "     TYPES ARE AS FOLLOWS:"
2740 PRINT "          1=SPECIFIC DATE ONLY"
2760 PRINT "          2=WEEKLY"
2780 PRINT "          3=BIWEEKLY"
2800 PRINT "          4=MONTHLY"
2820 PRINT "          5=BIMONTHLY"
2840 PRINT "          6=QUARTERLY"
2860 PRINT "          7=SEMI-ANNUALLY"
2880 PRINT "          8=ANNUALLY"
2900 PRINT "          9=EVERY N DAYS"
2920 PRINT
3020 GOTO 2600
3040 INPUT "ENTER DATE FOR NEW MESSAGE (YYMMDD)",M3
3050 IF M3<D9 M3=D9
3060 IF M3<>INT(M3) GOTO 3040
3070  D4=INT(M3/10000)
3080  D6=M3-D4*10000
3090  D5=INT(D6/100)
3100  D6=D6-D5*100
3180 IF ABS(D4-89)>11 GOTO 3040
3200 IF ABS(D5-6.5)>6 GOTO 3040
3220 IF ABS(D6-16)>15 GOTO 3040
3240 INPUT "ENTER MESSAGE",N$
3260 IF LEN(N$)<2 GOTO 3240
3280  A8=A8+1
3300 IF A8>A9 GOTO 3360
3320  A7=A(A8)
3340 IF A7>1 GOTO 3390
3350 IF A1<1 A1=1
3360  A1=A1+1
3380  A7=A1
3390 IF A1>=A2 GOTO 8800
3400 SET #10=A7
3420 GET #10
3440  N1=M1:N2=0:N3=M3:M$=N$
3450  N4=D9
3460 ON M1 GOTO 4000,3480,3520,3560,3600,3640,3680,3720,3760
3480  N2=7
3500 GOTO 4000
3520  N2=14
3540 GOTO 4000
3560  N2=1
3580 GOTO 4000
3600  N2=2
3620 GOTO 4000
3640  N2=3
3660 GOTO 4000
3680  N2=6
3700 GOTO 4000
3720  N2=12
3740 GOTO 4000
3760 INPUT "ENTER NUMBER OF DAYS",N2
3780 IF ABS(N2)<>INT(N2) GOTO 3760
3800 IF ABS(N2-500)>499 GOTO 3760
3820 GOTO 4000
4000 REWRITE #10
4020 GOTO 2600
6000 IF N1<2 RETURN
6020  I=INT(N3/10000)
6040  K=N3-I*10000
6060  J=INT(K/100)
6080  K=K-J*100
6100 IF I<1900 I=I+1900
6120 IF N1>3 GOTO 6300
6140 GOSUB 7000
6160  D=D+N2
6180 GOSUB 7200
6200  N3=((I-1900)*100+J)*100+K
6210 IF N3<D9 GOTO 6120
6220 RETURN
6300 IF N1=9 GOTO 6140
6320  J=J+N2
6340 IF J<13 GOTO 6400
6360  J=J-12
6380  I=I+1
6400 GOTO 6200
```

Listing 1 continued on page 164

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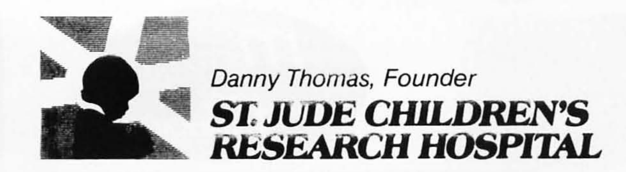
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Why should you help? Because St. Jude Children's Research Hospital knows no boundaries. Its impact is everywhere. Because you care.



Listing 1 continued:

```
6460 INPUT "ENTER NEW TO CLEAR DISK",Z$
6480 IF Z$<>"NEW" RETURN
6500 OPEN #10,"TICKLRX" FOR OUTPUT
6520 FIELD #10,N1=2,N2=3,N3=6,N4=6,M$=68
6540 INPUT "ENTER NUMBER OF MESSAGES TO BE HELD IN FILE",K
6550 IF ABS(K)<>INT(K) GOTO 6540
6560 IF K<100 K=100
6570  K=INT((K+2)/3)*3
6580  N1=0:N2=0:N3=1:N4=K:M$="TICKLER MESSAGE SYSTEM"
6600 PUT #10
6620  N3=0:N4=0:M$=" "
6640 FOR I=2 TO K
6650 PUT #10
6660 NEXT I
6680 CLOSE #10
6700 RETURN
7000 REM ASTRONOMICAL DAY (D) FROM YEAR (I),MONTH(J),DAY(K)
7020  T1=-INT((14-J)/12)
7040  T2=INT((1461*(I+4800+T1))/4)
7060  T3=INT((367*(J-2-T1*12))/12)
7080  T4=INT((3*INT((I+4900+T1)/100))/4)
7100  D=K-32075+T2+T3-T4
7120 RETURN
7200 REM YEAR(I),MONTH(J),DAY(K) FROM ASTRONOMICAL DAY(D)
7220  L=D+68569
7240  N=INT((4*L)/146097)
7260  I=INT((146097*N+3)/4)
7280  L=L-I
7300  I=INT((4000*(L+1))/1461001)
7320  J=INT((1461*I)/4)
7340  L=L-J+31
7360  J=INT((80*L)/2447)
7380  K=L-INT((2447*J)/80)
7400  L=INT(J/11)
7420  J=J+2-12*L
7440  I=100*(N-49)+I+L
7460 RETURN
8800 PRINT "FILE FULL OF MESSAGES NOW"
8900  A1=A2
9000 SET #10=1
9100 GET #10
9200  N1=0:N3=A1:N4=A2
9300 REWRITE #10
9400 CLOSE #10
9990 INPUT "INSERT PROGRAM DISK AND HIT RETURN",Z$
9999 END
```

data file record, shown in table 1. Since this defines an 85-byte record and each sector on the MSI disk (GSI 110) is 256 bytes in length, there will be three records per sector.

Lines 1400 through 1480 check the first record in the data file. If the message text is not TICKLER, the program assumes that the disk is not valid and asks the clerk if the disk should be cleared. Lines 1500 and 1600 retrieve the current and maximum end-of-file pointers from the first record in the file.

Control Options

Lines 1620 through 1680 request print-control for the current execution of the program. Options are explained in table 2. Lines 1700 through 1900 obtain the current date from the clerk and validate it. Line 1940 checks for run option of N (no printing) and, if it is N, skips the checking of the current messages.

Message Display

Lines 2000 through 2300 successively check every message in the file. Line 2020 reads the next record in the

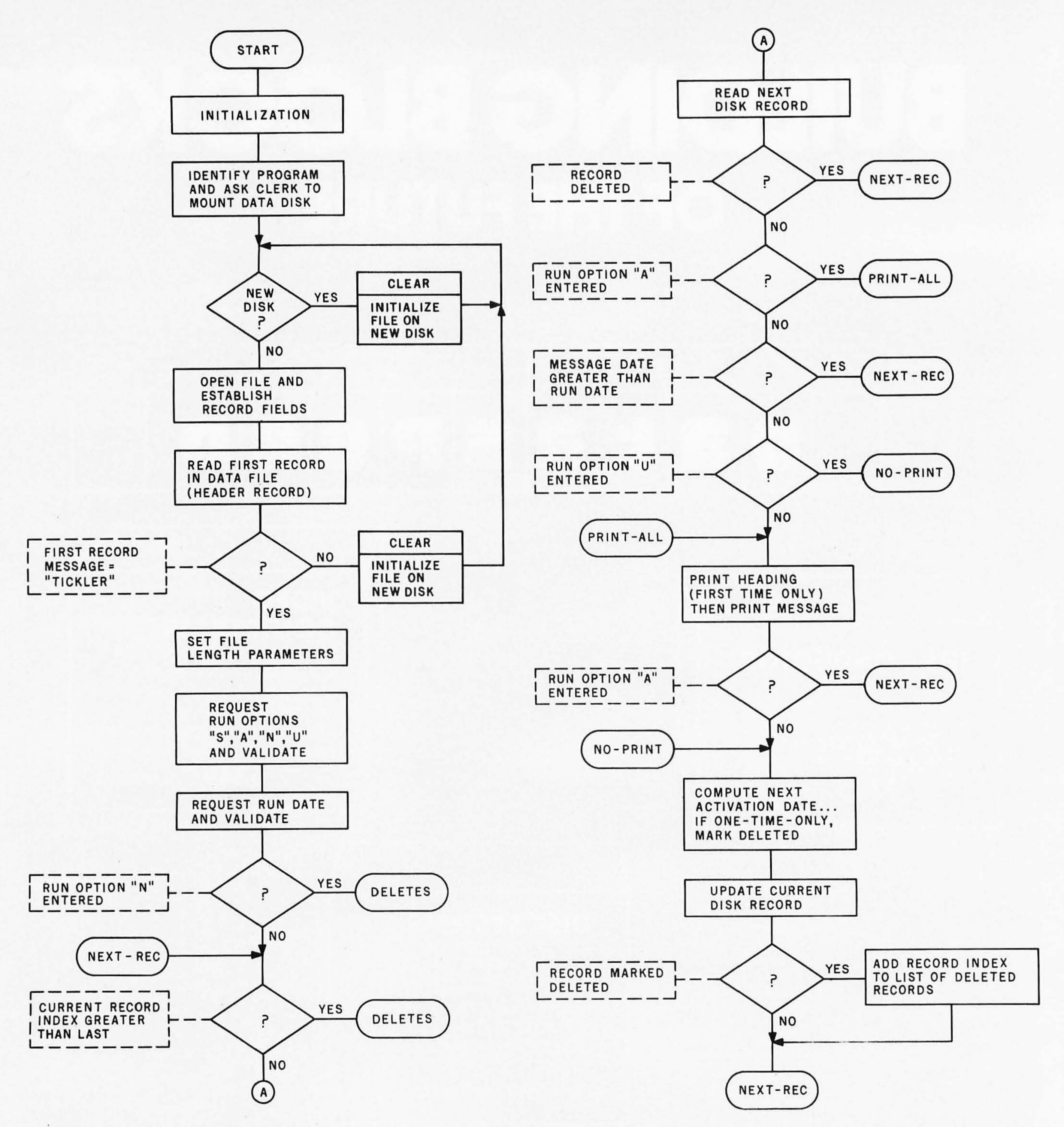


Figure 1: *Flowchart of a portion of the Tickler program that initializes disk files, selects options, prints messages, and computes new time intervals for the next activation of periodic messages.*

Variable	Description	External Length	Type
N1	Message type	2 bytes	Numeric
N2	Days	3 bytes	Numeric
N3	Message date	6 bytes	Numeric
N4	Date of last update	6 bytes	Numeric
M$	Message text	68 bytes	Character

Table 1: *Format of the data file record for opening data.*

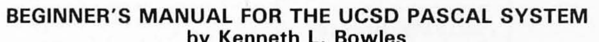
Option	Description
S	Selectively print and update messages
A	List all messages without updating dates
N	Only enter messages
U	Update message dates without listing

Table 2: *Options for updating messages.*

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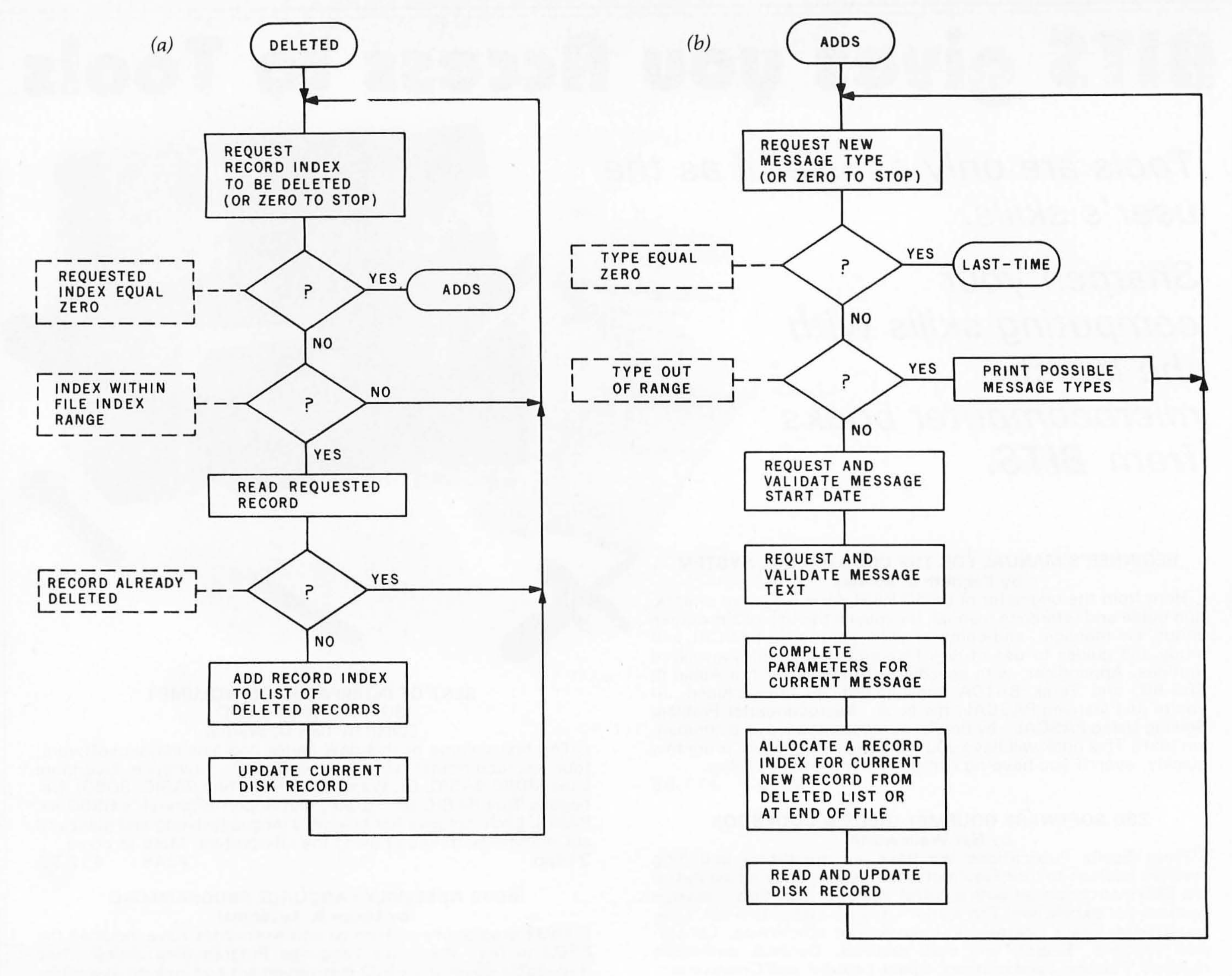


Figure 2: *Flowchart of (2a) the routine that deletes messages and (2b) the routine that adds messages to the file.*

file. Lines 2060 through 2090 check the print-control option and current date to determine if a given message is to be listed. Lines 2100 and 2120 print a heading before the first message. Lines 2145 through 2156 reduce the number of trailing blanks to be printed.

Line 2160 formats and prints the current message, along with entry number and type, expiration date, and date of last update. Line 2180 checks the print-control option for A (print all), and if it is A, bypasses updating the message date. Lines 2190 through 2220 update the message date and type, as required, on disk. Lines 2240 through 2280 add deleted record numbers to a table for later reuse.

Message Deletion

Lines 2320 through 2580 allow the clerk to delete additional lines from the file and add any deleted record numbers to the table described above. Deleted lines are recognized by having a message type of zero. Figure 2a shows the deletion procedure.

Entering New Messages

The message addition procedure is shown is figure 2b.

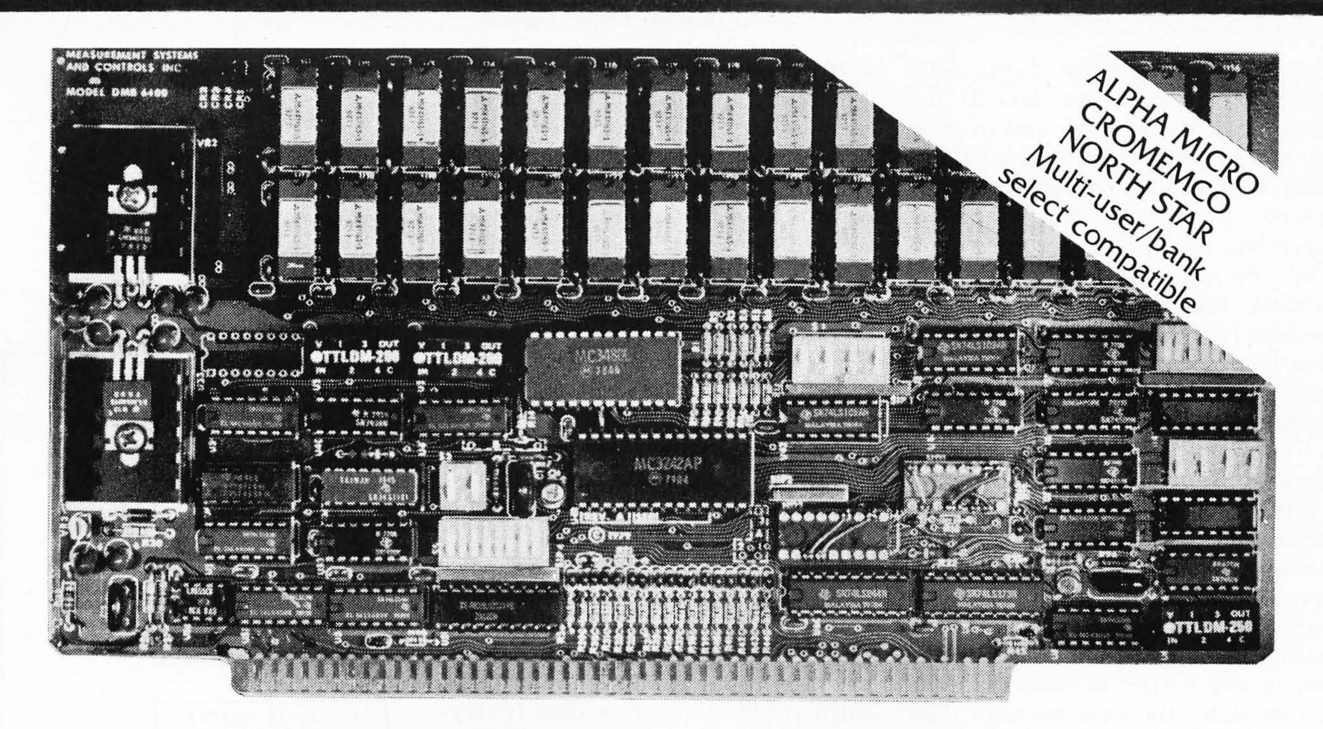
Lines 2600 through 4020 allow the clerk to enter new messages into the file. Line 2600 requests that a message type be entered. Line 2620 ensures that an integer value was keyed. Line 2640 checks this value for zero and, if it is zero, prepares to exit the program. Line 2660 checks this value for validity and, if it is not valid, causes the information on lines 2700 through 2920 to be printed. These lines identify the message types, shown in table 3.

Line 3020 returns to request that a new message type be entered for an invalid type entry. Lines 3040 through 3220 request that a date be entered to be used as an initial message date. Lines 3240 through 3260 request the clerk to enter the message text and ensure that something was entered.

Lines 3280 through 3390 attempt to allocate a record number for the new entry from those just deleted or at the

Type	Description
0	Deleted
1	Specific date only
2	Weekly
3	Biweekly
4	Monthly
5	Bimonthly
6	Quarterly
7	Semi-annually
8	Annually
9	Every N days

Table 3: *Message types available in the Tickler system. These values are contained in the M1 and N1 variables in the BASIC program.*



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end of the current file. Lines 3400 through 3450 read the data at the allocated record number and overlay the record with more current data. Lines 3460 through 3820 continue this process by filling in parameters depending upon message type. Lines 3760 through 3800 request and validate the number of days for message type 9 (repeat every N days). Line 4000 updates the record on disk. Line 4020 returns to request additional message entries.

Message Repetition

Lines 6000 through 6400 compute the next message activation date for a message whose current-activation interval has elapsed. It does this using the message type and old expiration date. If the newly computed message date is still earlier in time than the current date, the new message date becomes the old date, and the new message date is recomputed.

Data File Initialization

Lines 6460 through 6700 prepare a new-disk data file for use by the program. Lines 6460 and 6480 validate the format request. Lines 6500 and 6520 open the file for output, creating a new file, and provide the format of each record, as described earlier. Lines 6540 through 6570 request and validate the maximum number of records to be placed into the data file. Lines 6580 through 6660 format the records in the file. Line 6680 closes the file to complete the last sector and directory entry.

This disk-clearing subroutine is shown in flowchart form as figure 3.

Date Conversion

Lines 7000 through 7460 provide Gregorian date to Julian day number (as used by astronomers, a system that counts consecutive days since January 1, 4713 BC) conversions to help facilitate the process of recomputing the message activation date for message types 1, 2, 3, and 9. To calculate the Gregorian date N days from another, the following steps are performed:

1. Convert Gregorian date to Julian day number.
2. Add N to Julian day number.
3. Convert Julian day number to Gregorian date.

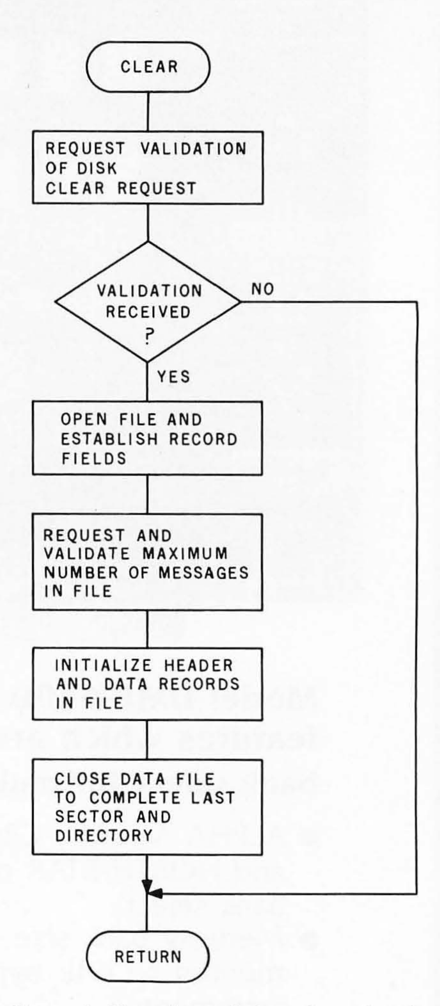


Figure 3: *Flowchart of the subroutine that initializes a new disk file.*

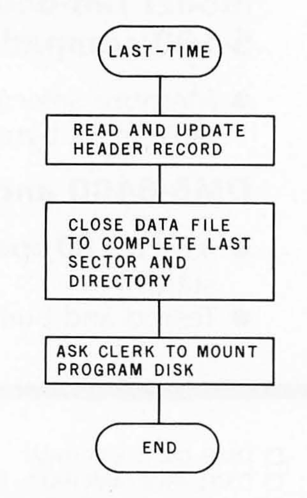


Figure 4: *Flowchart of the routine that terminates execution of the Tickler system in an orderly manner.*

Exit Procedures

A flowchart of the exit operations is shown as figure 4.

Lines 9000 through 9300 update the first record in the file, which contains

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Circle 104 on inquiry card.

Listing 2: *A sample series of executions of the Tickler program.*

```
#RUN
TICKLER MESSAGE SYSTEM
INSERT DATA DISK AND HIT RETURN?
ENTER PRINT CONTROL AS FOLLOWS:
  S=SELECTIVE,A=ALL,N=NONE,U=UPDATE ONLY ? N
ENTER CURRENT DATE (YYMMDD)? 790209
ENTER ENTRY NUMBERS TO BE DELETED, FOLLOWED BY ZERO? 0
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 99

     TYPES ARE AS FOLLOWS:
          1=SPECIFIC DATE ONLY
          2=WEEKLY
          3=BIWEEKLY
          4=MONTHLY
          5=BIMONTHLY
          6=QUARTERLY
          7=SEMI-ANNUALLY
          8=ANNUALLY
          9=EVERY N DAYS

ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 2
ENTER DATE FOR NEW MESSAGE (YYMMDD)? 79100210
ENTER MESSAGE? MESSAGE 1
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 3
ENTER DATE FOR NEW MESSAGE (YYMMDD)? 790220
ENTER MESSAGE? MESSAGE 2
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 4
ENTER DATE FOR NEW MESSAGE (YYMMDD)? 790301
ENTER MESSAGE? MESSAGE 3
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 5
ENTER DATE FOR NEW MESSAGE (YYMMDD)? 790215
ENTER MESSAGE? MESSAGE 4
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 6
ENTER DATE FOR NEW MESSAGE (YYMMDD)? 790305
ENTER MESSAGE? MESSAGE 5
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 7
ENTER DATE FOR NEW MESSAGE (YYMMDD)? 790401
ENTER MESSAGE? MESSAGE 6
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 8
ENTER DATE FOR NEW MESSAGE (YYMMDD)? 790601
ENTER MESSAGE? MESSAGE 7
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 9
ENTER DATE FOR NEW MESSAGE (YYMMDD)? 790209
ENTER MESSAGE? MESAGE 8
ENTER NUMBER OF DAYS? 10
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 1
ENTER DATE FOR NEW MESSAGE (YYMMDD)? 790401
ENTER MESSAGE? MESSAGE 9
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 0
INSERT PROGRAM DISK AND HIT RETURN?

MSI READY
#RUN
TICKLER MESSAGE SYSTEM
INSERT DATA DISK AND HIT RETURN?
ENTER PRINT CONTROL AS FOLLOWS:
  S=SELECTIVE,A=ALL,N=NONE,U=UPDATE ONLY ? A
ENTER CURRENT DATE (YYMMDD)? 790210


ENTRY TYPE  DATE    UPDATE       MESSAGE

  2     2   790210  790209       -MESSAGE 1
  3     3   790220  790209       -MESSAGE 2
  4     4   790301  790209       -MESSAGE 3
  5     5   790215  790209       -MESSAGE 4
  6     6   790305  790209       -MESSAGE 5
  7     7   790401  790209       -MESSAGE 6
  8     8   790601  790209       -MESSAGE 7
  9     9   790209  790209       -MESAGE 8
 10     1   790401  790209       -MESSAGE 9


ENTER ENTRY NUMBERS TO BE DELETED, FOLLOWED BY ZERO? 0
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 9
ENTER DATE FOR NEW MESSAGE (YYMMDD)? 790401
ENTER MESSAGE? MESSAGE 10
ENTER NUMBER OF DAYS? 24
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 0
INSERT PROGRAM DISK AND HIT RETURN?
```

```
MSI READY
#RUN
TICKLER MESSAGE SYSTEM
INSERT DATA DISK AND HIT RETURN?
ENTER PRINT CONTROL AS FOLLOWS:
  S=SELECTIVE,A=ALL,N=NONE,U=UPDATE ONLY ? S
ENTER CURRENT DATE (YYMMDD)? 790301


ENTRY TYPE  DATE    UPDATE       MESSAGE

  2     2   790210  790209       -MESSAGE 1
  3     3   790220  790209       -MESSAGE 2
  4     4   790301  790209       -MESSAGE 3
  5     5   790215  790209       -MESSAGE 4
  9     9   790209  790209       -MESAGE 8


ENTER ENTRY NUMBERS TO BE DELETED, FOLLOWED BY ZERO? 9
  9  DELETED
ENTER ENTRY NUMBERS TO BE DELETED, FOLLOWED BY ZERO? 0
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 0
INSERT PROGRAM DISK AND HIT RETURN?

MSI READY
#RUN
TICKLER MESSAGE SYSTEM
INSERT DATA DISK AND HIT RETURN?
ENTER PRINT CONTROL AS FOLLOWS:
  S=SELECTIVE,A=ALL,N=NONE,U=UPDATE ONLY ? S
ENTER CURRENT DATE (YYMMDD)? 790501


ENTRY TYPE  DATE    UPDATE       MESSAGE

  2     2   790303  790301       -MESSAGE 1
  3     3   790306  790301       -MESSAGE 2
  4     4   790401  790301       -MESSAGE 3
  5     5   790415  790301       -MESSAGE 4
  6     6   790305  790209       -MESSAGE 5
  7     7   790401  790209       -MESSAGE 6
 10     1   790401  790209       -MESSAGE 9
 11     9   790401  790210       -MESSAGE 10


ENTER ENTRY NUMBERS TO BE DELETED, FOLLOWED BY ZERO? 0
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 0
INSERT PROGRAM DISK AND HIT RETURN?

MSI READY
#RU

RU
↑ - ERROR # 03

MSI READY
#RUN
TICKLER MESSAGE SYSTEM
INSERT DATA DISK AND HIT RETURN?
ENTER PRINT CONTROL AS FOLLOWS:
  S=SELECTIVE,A=ALL,N=NONE,U=UPDATE ONLY ? S
ENTER CURRENT DATE (YYMMDD)? 790502


ENTRY TYPE  DATE    UPDATE       MESSAGE

  3     3   790501  790501       -MESSAGE 2
  4     4   790501  790501       -MESSAGE 3


ENTER ENTRY NUMBERS TO BE DELETED, FOLLOWED BY ZERO? 0
ENTER TYPE FOR NEW MESSAGE (0=QUIT,99=HELP)? 0
INSERT PROGRAM DISK AND HIT RETURN?

MSI READY
```

current and last record numbers. Line 9400 closes the file to update the first record and directory entry.

Line 9500 restores the input routine so that commas become string delimiters once again. Line 9990 requests the clerk to insert the program disk and acknowledge this action.

If you or your business have the problem of needing one-time or periodic reminders, then this program should be worth the effort it takes to key it in (and convert it, if necessary). There are rewards for using it and penalties for not using it. ■

Programming Quickies

A Pascal Checkbook Balancing Program

Carl T Helmers, Editorial Director, BYTE Publications

Probably the most hackneyed example of what one can do with a personal computer is the proverbial checkbook balancing program. Well, here I have gone and done it: I sat down and profaned Pascal by writing a simple little interactive checkbook balance figuring program (listing 1).

The interactive sequence at initialization reflects a hardware specific aspect of a system which has UCSD Pascal bootstrapped through the CP/M operating system's "BIOS" drivers. This is the use of the "<control> P" character from the keyboard to toggle a single bit flag which determines whether or not the printer is on. We assume the program is off upon entry, so that one depression of the <control> P character will turn on the printer through the "BIOS" keyboard driver's action.

The general outline of the program, found in the last eight non-blank lines of listing 1, is fairly standard and applicable to a host of specific uses. For nearly every use of a computer, we start with a procedure called *initialization* which sets up the necessary initial conditions of processing. Then, we continue with a *repeat until done* loop construct which does the main logic of the process over and over again.

When the flag *done* becomes true during the main logic, the repeat loop discontinues and we fall through to the standard procedure *summarize* which does any final processing before the program is complete. Of course, in this particular example, *summarize* is a null operation, since I have no particular need to provide any reporting or file operations other than those encountered in the main loop. I have left the dummy procedure *summarize* in the listing to document this need for a possible summary procedure in a more elaborate version of the same program.

This program is run in UCSD Pascal, version 1.5. This same program should run identically on any computer with the UCSD Pascal software system. A sample run follows the listing. I have used the program now for several months; the interactive sequence used for all the detailed computations could be much improved, even though the present form has proved quite practical.

Listing 1: *A Pascal listing of the checkbook balancing program.*

```
PROGRAM checks;
   { A simple little program written March 26 1979  by Carl Helmers }
   { Time from inception to working program approximately 15 minutes }


  VAR
     done : BOOLEAN;
     detail,balance : REAL;
     anychar : CHAR;
     count : INTEGER;


  PROCEDURE initialize;
     BEGIN
        balance := 0;
        count := 0;

        {The following sequence turns on my printer if I type <ctrl P> }
        PAGE(OUTPUT);
        WRITELN('Checkbook balancer program');
        WRITELN('Set printer to top of form, press <ctrl P>, then any key.');
        READ(KEYBOARD,anychar);

        {Premature end of program if I type <esc> now}
        IF anychar = CHR(27) THEN done := TRUE
        ELSE done := FALSE;

        {A sequence to get the initial balance...}
        IF NOT done THEN
           BEGIN
              anychar := 'N';
              REPEAT
                 WRITELN('');
                 WRITELN('Enter Initial Balance');
                 READLN(balance);
                 WRITELN('Balance Starts at ',balance:10:2);
                 WRITELN('Is this correct?');
                 READ(KEYBOARD,anychar);
                 WRITELN(anychar)
              UNTIL ((anychar='y') OR (anychar='Y'))
           END;
     END {initialize};

PROCEDURE process_one_check;
  VAR
     s : STRING[50];
```

```
PROCEDURE get_charge;
  BEGIN
    anychar := 'N';
    REPEAT
      WRITELN('Enter amount of ',s,': ');
      READLN(detail);
      WRITELN('Is ',detail:10:2,' the correct value of the ',s,
          '? ');
      READ(KEYBOARD,anychar)
    UNTIL ((anychar='y') OR (anychar='Y'))
  END {get_charge};


PROCEDURE display_balance;
  BEGIN
    WRITELN('              Current Balance = ',balance:10:2)
  END {display_balance};


BEGIN {process_one_check}
  WRITELN('');
  WRITELN('C? D? I? or <esc>');
  READ(KEYBOARD,anychar);
  WRITELN(anychar);
  IF anychar = CHR(27)
  THEN
    done := TRUE
  ELSE

    CASE anychar OF

      'C','c':
        BEGIN
          s := 'check';
          get_charge;
          balance := balance - detail;
          display_balance
        END;

      'D','d':
        BEGIN
          s := 'deposit';
          get_charge;
          balance := balance + detail;
          display_balance
        END;

      'I','i':
        BEGIN
          s := 'interest';
          get_charge;
          balance := balance + detail;
          display_balance
        END

    END {CASE};

END {process_one_check};


PROCEDURE summarize;
  BEGIN
    {Remarkable... this procedure doesn't do anything!}
  END {summarize};



BEGIN {checks}

  {isn't this simple... all we do is }
  initialize;
  REPEAT
    process_one_check
  UNTIL done;
  summarize

END.
```

Listing 2: *A sample run.*

```
Checkbook balancer program
Set printer to top of form, press <ctrl P>, then any key.

Enter Initial Balance
3.1415927
Balance Starts at       3.14
Is this correct?
n
Enter Initial Balance
1000
Balance Starts at  1000.00
Is this correct?
y

C? D? I? or <esc>
c
Enter amount of check:
15
Is     15.00 the correct value of the check?
                Current Balance =    985.00

C? D? I? or <esc>
3

C? D? I? or <esc>
2

C? D? I? or <esc>
c
Enter amount of check:
32.98
Is     32.98 the correct value of the check?
                Current Balance =    952.02

C? D? I? or <esc>
i
Enter amount of interest:
2
Is      2.00 the correct value of the interest?
                Current Balance =    954.02

C? D? I? or <esc>
d
Enter amount of deposit:
1000
Is   1000.00 the correct value of the deposit?
                Current Balance =   1954.02

C? D? I? or <esc>
c
Enter amount of check:
270
Is    270.00 the correct value of the check?
                Current Balance =   1684.02

C? D? I? or <esc> ■
```

Illustrating BASIC

Donald Alcock
Cambridge University Press, 1977
134 pages, softcover with ring binding $4.95
hardcover $14.95

If you are looking for a good introductory BASIC text containing informative illustrations, short programs, a fundamental approach to programming in BASIC, and if you enjoy reading a unique typeset format, then *Illustrating BASIC* by Donald Alcock, is for you.

In order to set the general approach used throughout this book, the author presents a line drawing of the famous program "bug." This is but one of the many "biff! bam! pow!" Batman and Robin type inserts used to reinforce specific concepts as they develop. This approach leads the reader through a convenient how-to-do-it explanation of BASIC programming.

The first chapter introduces the reader to what the author calls "Components of the Language." Immediately, the reader gets a taste of the unique presentation offered by this book; illustrations, short programs, and interesting problems abound. The fundamental concepts of most BASICs are introduced via a short note, an illustration, and a few program lines which allow the reader to see how the program should appear. Numeric variables (integer, real, and exponent form) and text variables (strings) are presented in a short but thorough exposition.

Chapter 2, entitled "Input and Output, Expressions and Functions," covers the statements: DATA; READ; RESTORE; INPUT; the functions SGN, ABS, SQR, INT, LOG, EXP, SIN, COS, TAN, and ATN; RND; DEF; PRINT; TAB; and PRINT USING. For each of these statements, a simple illustrative program is given. For example, an engineer may be interested in the short routine that calculates the spring properties of a diving board; the businessman will find the monthly repayment on a loan useful; the game player can use the die throwing routine; the mathematician has a routine that plots the graph of the cosine function; and everyone should enjoy the examples given for the PRINT USING statement.

After these concepts is Chapter 3, "Control." As in every chapter, the pertinent statements such as GOTO, IF. . . THEN, STOP, ON . . .GOTO, FOR . . . NEXT, GOSUB, and RETURN are introduced, illustrated, and programmed into short routines. Chapter

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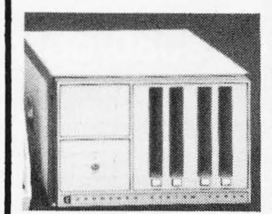
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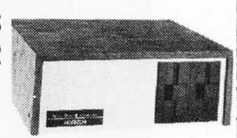
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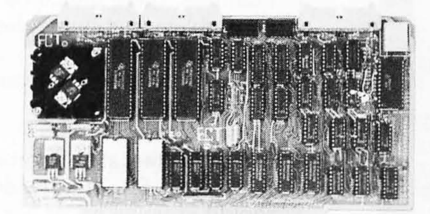


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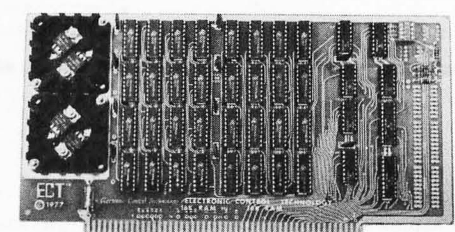
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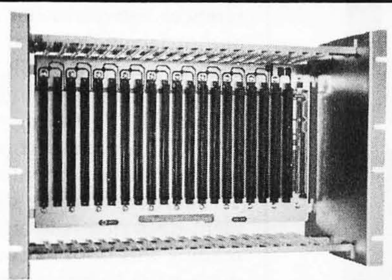
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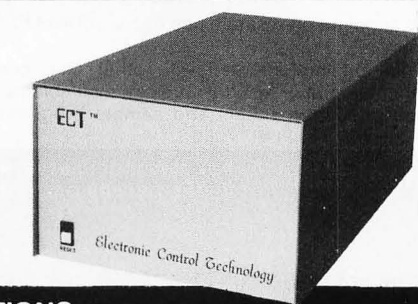
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3 does just that with the GOTO. Some of the programs include: solving a pair of simultaneous equations having any number of right-hand sides; area calculations for triangles, rectangles, and circles; and the game of Moo (quite similar to Bulls and Cows; ie: a number-based Mastermind).

A useful routine in Chapter 3 introduces the reader to stacks and to the concept of recursion via the GOSUB statement. This by-the-way approach of introducing and examining a relatively complex idea is done rather subtly and painlessly.

Arrays are covered quite well in Chapter 4, and matrix operations are presented in Chapter 5. The concepts in Chapter 4 concerning arrays are enhanced when the reader finishes examining the matrices in Chapter 5. The author explains and illustrates matrix functions, although not all BASIC systems have them. He then manipulates matrices without the functions, using nested loops. Some of the more interesting matrix operations include: arithmetic operations upon arrays; transposing a matrix; initializing an array to all zeros or all ones; inverting a matrix; and input and output statements performed on arrays.

The array manipulating routines deal primarily with matrix algebra applications and could prove useful to the engineer or the mathematician.

Chapter 6, entitled "Complete Example Programs," contains only two programs. The first is a routine which converts Roman numerals to Hindu-Arabic (such as VII to 7). The other program is a critical-path analysis routine. Expecting a host of programs in this chapter, I was disappointed to find only two. They are good example programs which bring together most everything the reader has seen so far. Perhaps they could have been included as wrap-up programs in other chapters.

The remaining three chapters ("Commands and Signing On," "Files of Data," and "Syntax") explain how the typical BASIC interpreter handles the RUN, SAVE, UNSAVE, OLD, NEW, and CATALOG commands (the reader is cautioned as to the particulars of his or her personal BASIC); a typical sign-on session (see your owner's manual for this one); a short (unfortunately) discussion pertaining to sequential and direct-access files; and a modified Backus-Naur notation used to summarize the syntax of BASIC.

I ran most of the examples presented in the text on my Level II TRS-80. Since the author does not use any machine- or interpreter-dependent statements in his examples, there should be no problem in running the examples on other microcomputers. Some caution is expressed by the author, however, with regard to the lack of portability of BASIC. The reader should examine his or her BASIC manual for any differences between what the author labels "minimal BASIC" and the BASIC used in the reader's computer.

Overall, *Illustrating BASIC* is a good first book for the novice computerist. The author's Preface statement does ring true after reading this book: "You don't have to be a computer scientist to read this book: It is for students meeting computers for the first time; for those in industry (parti-



cularly engineers) who never formally studied computing but would like to write simple computer programs; for managers who do not want to write programs but would like to know more about a field in which they often have to take decisions; and for those who can already write in BASIC but seek a broader view of portable programming and an introduction to a few programmers' techniques like state tables and list processing."

Len Gorney
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Salisbury Rd
Clarks Summit PA 18411

Implementing Software for Non-Numeric Applications

William M Waite
Prentice-Hall, 1973
110 pages hardcover
$21.00

Implementing Software for Non-Numeric Applications is a textbook on list and string processing languages. It covers the basics of lists and strings, and how to implement languages in order to deal with these data types. There are two major reasons why a computer hobbyist might want to read this book: to learn how such languages work and to learn how to implement them.

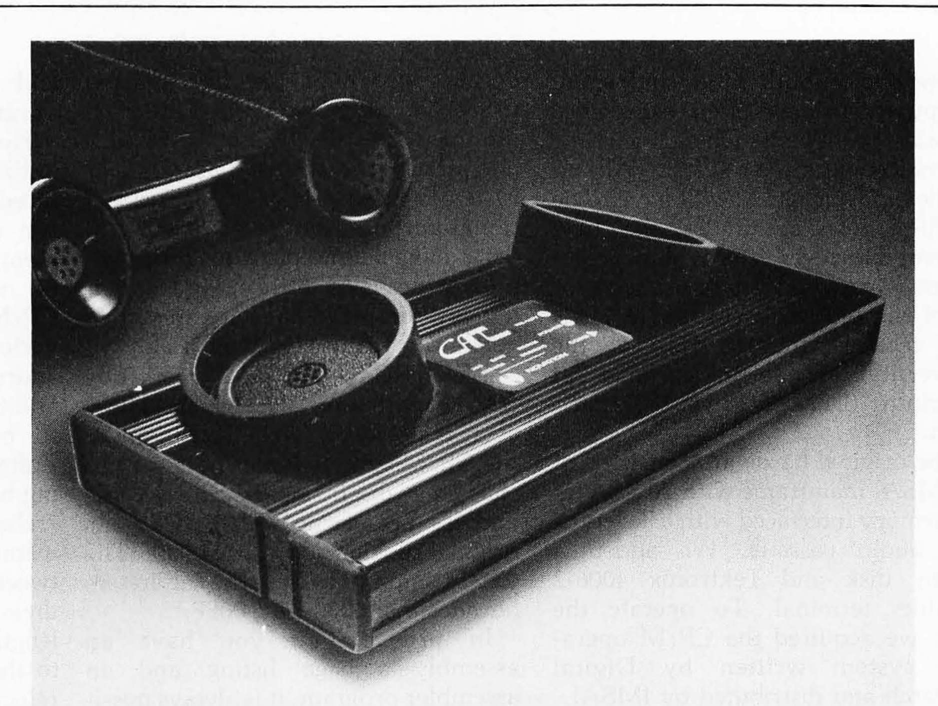
Most of the book is about lists. It begins with a discussion of what lists are, and then presents an ideal machine for processing them (cf Pascal p-code), a fairly simple list processing language called HELP, and then LISP. The discussion of LISP focuses fairly heavily on what LISP does internally and why. After more discussion of complex lists, the book proceeds to a discussion of strings; SNOBOL4 is introduced but not discussed in the detail that LISP is treated. The final section is on implementation.

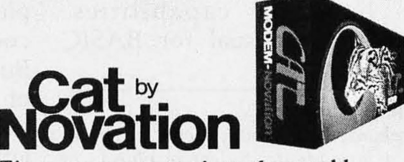
The author of the book favors implementation by abstract machine modeling; this is the way in which Pascal is implemented. It has the advantage that a compiler or interpreter, once written, can be implemented on new machines with much less effort than would otherwise be the case. The discussion of implementation is more than just theoretical; the appendices contain complete FORTRAN listings for an abstract machine model, and for HELP language compiler and interpreter.

HELP is a language similar to LISP. The software may be directly implemented if you have a FORTRAN compiler; otherwise it has to be translated into assembler (or perhaps BASIC, if execution speed is not important). I cannot say how successful this would be; I already have LISP for my Z80 processor and so was not tempted to implement HELP.

In conclusion, this book is fairly heavy going. If you want a thorough introduction to how list languages work, why they do what they do, and how to implement them, this is an excellent book. If you want an introduction to LISP, it would probably be better to first read an introductory text. Then read *Implementing Software for Non-Numeric Applications* to really understand the way things work.

John A Lehman
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Ann Arbor MI 48103 ■





Relocating 8080 System Software

John G Lipham
Dept of Physics
University of North Carolina
at Charlotte
Charlotte NC 28223

Owners of both large and small computer systems often experience software problems when the time comes to upgrade the system. All old applications programs will have to be modified to run under the new system. However, the real problem occurs when you want to use some or all of the old system software. This was recently the situation at the University of North Carolina at Charlotte (UNCC) Physics Department.

The original hardware consisted of an IMSAI mainframe with 20 K bytes of memory interfaced with a Teletype and audio cassette. We added a floppy disk and Tektronix 4006-2 graphics terminal. To operate the disk, we acquired the CP/M operating system written by Digital Research and distributed by IMSAI.

The CP/M system has a disk-based version of BASIC called BASIC-E, which was written by Gordon Eubanks. This is an excellent version that allows up to 31 characters for variable names, nearly form-free entry of statements with line numbers required only for program transfer (eg: GOTO ..., GOSUB ..., etc), and numerous built-in functions, as well as file handling capabilities. However, it is unusual for BASIC because programs are first created using an editor, compiled into an intermediate file (using BASIC-E), and finally run (using RUN-E). Our system is used primarily for instructional purposes and some of our students have had no previous programming experience. Hence, we felt that it was desirable to have an interactive version of BASIC for their use.

We already had an interactive BASIC with our old system. However, there was a catch. To run under the CP/M system, it was necessary to shift the origin of BASIC to the address hexadecimal 0100 from its original starting address of 0000. (The CP/M monitor uses the addresses hexadecimal 0000 thru 00FF.)

In principle, if you have an assembly-language listing and an assembler program, it is always possible to reassemble the assembly-language code to machine code with a new starting address. However, with our old version of BASIC, this listing consisted of 113 typed pages! Ignoring the difficulty of just entering this amount of code, a moment's reflection will show that the assembler and the code would never fit in 20 K bytes. (The machine code itself occupies about 9 K bytes.) Assembling the code in pieces that fit is a possibility. But, even with a cross-reference table of variable names, this would be an excruciating process. Hence, we were left with the only practicable alternative: relocating the machine code directly.

Thus it was with great interest that I read Leor Zolman's article in the July 1977 BYTE entitled "A Machine Code Relocator for the 8080." I have used the program written by Zolman and have found that it works as advertised.

However, I have oversimplified my initial statement of the problems faced in modifying our old BASIC to run under CP/M. There were segments of the old software that had to be removed to be compatible with CP/M. Thus, to avoid a lot of NOPs, various relocations to lower-memory addresses had to be made. (Various additions and replacements also had to be made.) As pointed out by Zolman, his program works by moving blocks of code tail-to-tail. Hence, "relocating backward into lower memory fails if the difference between the source and destination address is not greater than the block length." Also, his suggested solution to this limitation of performing two relocations was impracticable because of our memory limitations.

I found that by making some modifications I could remove the limitation in Zolman's original program at the cost of 36 additional bytes of program code. This modified relocator program is presented in listing 1. As written, the program is designed to run with the CP/M system's Dynamic Debugging Tool (DDT), which is a type of monitor program for machine-code programs. I found this to be a useful procedure, since the Dynamic Debugging Tool allows the machine's memory to be reviewed and modified via a terminal keyboard. I also found the disassembler routine of this program to be invaluable. (The program can be modified to run without a monitor, or with another monitor, by changing memory location hexadecimal 2DCC.)

About the Author

John Lipham's first contact with programming was as a graduate student in physics at the University of North Carolina at Chapel Hill. There he discovered PL/1 and assembly language for the IBM 360. Recently he has been working with a colleague on a project using an IMSAI microcomputer system. The goal of the project is to develop software to aid in teaching physics, and to interface the system to scientific instruments for research purposes.

While there are some differences in detail as to the operation of the modified relocator, this program is run in the same manner as Zolman's original program. For ease of reference I have retained Zolman's nomenclature. (nb: Using this nomenclature, you view the memory as though you were looking down into a barrel. Numerically smaller addresses are at the top and numerically larger ones are at the bottom.) The same pieces of information are required for a relocation and reference fix, as in Zolman's program. This required information is outlined in table 1, which, except for memory addresses, is the same as Zolman's.

The LXI Problem

As pointed out by Zolman, the load immediate (LXI) instruction is a potential source of problems in relocating machine-code programs. The main difficulty is that this instruction is frequently used for two different jobs: to load a constant into a register pair, and to load an address into a register pair. The relocator program cannot distinguish between these two uses. Hence, if a program constant happens to be equal to an address within the program block being moved, an erroneous reference fix will be made.

Unfortunately there seem to be no widely accepted conventions for the use of this instruction that produce easily relocatable machine code. Adoption of the following conventions is suggested for all those desiring to write relocatable code:

(1) The LXI instruction shall be used only to load addresses into a register pair (eg: LXI H,3101H).

(2) All program constants shall be loaded into a register pair using 2 move immediate instructions (eg: MVI H,31H MVI L,01H).

The cost of adopting these conventions is relatively modest in that it will take 4 bytes to load a 2-byte constant into a register pair, instead of the 3 bytes required using the LXI instruction. Furthermore, if you only want to zero out a register pair, the following sequence of instructions achieves the same result at no additional cost, without using the LXI instruction:

Listing 1: *A relocator program for use on 8080 systems. This is a modified version of the relocator program written by Leor Zolman in the July 1977 BYTE. This relocator will move a source program to any location in memory and fix address references. Relocations of a source-program block to any address outside the source are performed without overwriting. The program is designed to run with the Dynamic Debugging Tool (DDT) of the CP/M software system. If need be, the program can be modified to run without a monitor or with another monitor by changing the contents of hexadecimal memory location 2DCC. While differing in some details with Zolman's relocator program, it requires the same information and is run in the same manner.*

```
2D00                        ORG     2D00H          ;SET ORIGIN
2D00 31162E     BEGIN:      LXI     SP,STACK+8     ;INTIALIZE STACK
2D03 2A032E                 LHLD    SBOT           ;BOTTOM OF SOURCE
2D06 EB                     XCHG                   ;D,E=SBOT=(B)
2D07 2A012E                 LHLD    SSTRT          ;H,L=SSTRT=(A)
2D0A 4D                     MOV     C,L
2D0B 44                     MOV     B,H            ;SAVE IN B,C
2D0C CDCD2D                 CALL    COMPH          ;COMPLIMENT(A) & ADD 1
2D0F 19                     DAD     D              ;H,L=(B)-(A)=BLOCKSIZE
2D10 E5                     PUSH    H              ;SAVE ON STACK
2D11 2A052E                 LHLD    DTOP           ;TOP OF DESTINATION
2D14 EB                     XCHG                   ;D,E=DTOP=(C)
2D15 69                     MOV     L,C
2D16 60                     MOV     H,B            ;H,L=SSTRT
2D17 CDCD2D                 CALL    COMPH
2D1A 19                     DAD     D              ;H,L=(C)-(A)=DISPL
2D1B 220C2E                 SHLD    DISPL          ;SAVE DISPLACEMENT
2D1E F5                     PUSH    PSW            ;HAS SIGN OF DISPL
2D1F 3A0B2E                 LDA     FUNC           ;CHECK FOR MOVE
2D22 B7                     ORA     A
2D23 CA602D                 JZ      STEP2          ;IF 0 FIX REF. ONLY
2D26 F1                     POP     PSW
2D27 DA3E2D                 JC      DOWN           ;(C)>(A) IF CARRY SET
                        ;IF COME HERE DESTINATION IS ABOVE SOURCE
                        ;SO MOVE IS DONE HEAD-TO-HEAD
2D2A EB         UP:         XCHG                   ;H,L=D,E=DTOP
2D2B D1                     POP     D              ;D,E=BLKSIZE
2D2C 0A         X:          LDAX    B              ;B,C=SSTRT=SOURCE PTR.
2D2D 77                     MOV     M,A            ;MOVE TO NEW LOC.
2D2E 7A                     MOV     A,D
2D2F B7                     ORA     A
2D30 C2382D                 JNZ     Y              ;CHECK IF THRU
2D33 7B                     MOV     A,E
2D34 B7                     ORA     A
2D35 CA582D                 JZ      TEST           ;IF D,E=0 THEN MOVE DONE
2D38 23         Y:          INX     H              ;INCR DEST. PTR. TO NEXT
2D39 03                     INX     B              ;INCR SOURCE PTR.
2D3A 1B                     DCX     D              ;COUNT DOWN BLKSIZE
2D3B C32C2D                 JMP     X              ;CONTINUE
                        ;IF COME HERE DESTINATION IS BELOW SOURCE
                        ;SO MOVE IS DONE TAIL-TO-TAIL
2D3E EB         DOWN:       XCHG                   ;H,L=D,E=DTOP
2D3F D1                     POP     D              ;D,E=BLKSIZE
2D40 D5                     PUSH    D              ;SAVE ON STACK
2D41 19                     DAD     D              ;H,L=DBOT=DTOP+BLKSIZE
2D42 EB                     XCHG                   ;D,E=DBOT:H,L=BLKSIZE
2D43 09                     DAD     B              ;H,L=SSTRT+BLKSIZE=SBOT
2D44 EB                     XCHG                   ;D,E=SBOT:H,L=DBOT
2D45 C1                     POP     B              ;B,C=BLKSIZE
2D46 1A         XX:         LDAX    D              ;D,E=SOURCE PTR.
2D47 77                     MOV     M,A            ;MOVE TO NEW LOC.
2D48 78                     MOV     A,B
2D49 B7                     ORA     A
2D4A C2522D                 JNZ     YY             ;CHECK IF THRU
2D4D 79                     MOV     A,C
2D4E B7                     ORA     A
2D4F CA582D                 JZ      TEST           ;B,C=0,MOVE DONE
2D52 2B         YY:         DCX     H              ;PT. TO NEXT DEST.
2D53 1B                     DCX     D              ;PT. TO NEXT SOURCE
2D54 0B                     DCX     B              ;COUNT DOWN BLKSIZE
2D55 C3462D                 JMP     XX             ;CONTINUE
2D58 3A0B2E     TEST:       LDA     FUNC           ;=02 IF MOVE ONLY
2D5B FE02                   CPI     02H
2D5D CACC2D                 JZ      DONE
                        ;COME HERE TO DO REFERENCE FIXING.
                        ;NECESSARY ONLY FOR 3 BYTE OP CODES
2D60 01E72D     STEP2:      LXI     B,TABL3        ;B,C= TABLE PTR
2D63 2A032E                 LHLD    SBOT           ;NEED TO ADD 1 TO SBOT
2D66 23                     INX     H
2D67 22032E                 SHLD    SBOT
2D6A 2A072E                 LHLD    START          ;D,E=MEMORY PTR.
2D6D EB                     XCHG
2D6E 2A092E     CHEKF:      LHLD    SSTP           ;CHECK FOR END OF FILE
2D71 CDCD2D                 CALL    COMPH          ;D,E=MEM.PTR.
```

Listing 1 continued on page 184

Listing 1 continued:

```
2D74 19                  DAD    D             ;D,E-H,L=DIFF.
2D75 DACC2D              JC     DONE          ;DIFF.>=0,CARRY SET
2D78 1A        NEXT:     LDAX   D             ;LOAD MEM. USING D,E
2D79 67                  MOV    H,A           ;SAVE IN H
2D7A AF                  XRA    A             ;ZERO ACCUM.
2D7B 6F                  MOV    L,A           ;SET UP CNTR.
2D7C 2C        COMP3:    INR    L             ;BUMP CNTR
2D7D 7D                  MOV    A,L
2D7E FE1B                CPI    27D           ;CHECK FOR END OF TABLE
2D80 CA8C2D              JZ     AGAIN         ;IF THRU,LOOK @ 2 BYT OPS
2D83 0A                  LDAX   B             ;LOAD TABLE ENTRY
2D84 94                  SUB    H             ;COMP. WITH CURR. MEM.
2D85 CAA12D              JZ     MTCH3         ;JMP IF MATCH
2D88 03                  INX    B             ;ELSE BUMP TABLE PTR.
2D89 C37C2D              JMP    COMP3         ;LOOK AGAIN
2D8C 01D52D    AGAIN:    LXI    B,TABL2       ;NOW,LOOK AT 2 BYTE OPS
2D8F AF                  XRA    A             ;ZERO ACCUM.
2D90 6F                  MOV    L,A           ;SET CTR.
2D91 2C        COMP2:    INR    L             ;BUMP CTR.
2D92 7D                  MOV    A,L
2D93 FE13                CPI    19D           ;CHECK FOR END TABLE
2D95 CAC52D              JZ     OUT1          ;NO MATCH 2 OR 3 BYTE OPS
2D98 0A                  LDAX   B             ;LOAD TABLE ENTRY
2D99 94                  SUB    H             ;COMP. WITH CURRENT MEM.
2D9A CAC42D              JZ     OUT2          ;JMP IF MATCH
2D9D 03                  INX    B             ;ELSE BUMP TABLE PTR.
2D9E C3912D              JMP    COMP2         ;LOOK AGAIN
2DA1 2A032E    MTCH3:    LHLD   SBOT          ;FOUND 3 BYTE OP CODE
2DA4 CDCD2D              CALL   COMPH         ;IS ADDR. IN RANGE?
2DA7 13                  INX    D             ;GET LO ADDR. BYTE
2DA8 1A                  LDAX   D             ;LOAD IN ACC.
2DA9 4F                  MOV    C,A           ;STORE IN C
2DAA 13                  INX    D             ;GET HI ADDR. BYTE
2DAB 1A                  LDAX   D             ;LOAD ACC.
2DAC 47                  MOV    B,A           ;PUT IN B
2DAD 09                  DAD    B             ;H,L=MEM.ADDR.-SBOT
2DAE DAC52D              JC     OUT1          ;MEM.ADDR.>=SBOT+1,C SET
2DB1 2A012E              LHLD   SSTRT         ;LESS THAN (A)?
2DB4 CDCD2D              CALL   COMPH
2DB7 09                  DAD    B             ;H,L=MEM. ADDR.-SSTRT
2DB8 D2C52D              JNC    OUT1          ;MEM.ADDR. < SSTRT,C=0
2DBB 2A0C2E    FIXR:     LHLD   DISPL         ;IF COME HERE,IN RANGE.
2DBE 09                  DAD    B             ;H,L=MEM.ADDR.+DISPL
2DBF 7C                  MOV    A,H
2DC0 12                  STAX   D             ;STORE NEW HI ADDR.
2DC1 1B                  DCX    D             ;PT. AT LO ADDR. BYTE
2DC2 7D                  MOV    A,L
2DC3 12                  STAX   D             ;STORE NEW LO ADDR. BYTE
2DC4 13        OUT2:     INX    D
2DC5 13        OUT1:     INX    D             ;ADV. PTR. TO NEXT OP
2DC6 01E72D              LXI    B,TABL3       ;RESET TABLE PTR.
2DC9 C36E2D              JMP    CHEKF         ;CONTINUE
2DCC FF        DONE:     RST    07            ;FINIS,RETURN TO DDT
                        ;*****  SUBROUTINE  *****
2DCD 7C        COMPH:    MOV    A,H           ;SUBROUTINE USED TO
2DCE 2F                  CMA                  ;FIND 2'S COMPLIMENT
2DCF 67                  MOV    H,A           ;REPRESENTATION OF
2DD0 7D                  MOV    A,L           ;H,L REGISTER PAIR
2DD1 2F                  CMA
2DD2 6F                  MOV    L,A
2DD3 23                  INX    H
2DD4 C9                  RET
                        ;*****  TABLES AND CONSTANTS  *****
2DD5 060E16    TABL2:    DB 06H,0EH,16H       ;TABLE OF 2 BYTE
2DD8 1E262E              DB 1EH,26H,2EH       ;OP CODES
2DDB 363EC6              DB 36H,3EH,0C6H
2DDE CEDED6              DB 0CEH,0DEH,0D6H
2DE1 DBDEE6              DB 0DBH,0DEH,0E6H
2DE4 EEF6FE              DB 0EEH,0F6H,0FEH
2DE7 011121    TABL3:    DB 01H,11H,21H       ;TABLE OF 3 BYTE
2DEA 222A31              DB 22H,2AH,31H       ;OP CODES
2DED 323AC2              DB 32H,3AH,0C2H
2DF0 C3C4CA              DB 0C3H,0C4H,0CAH
2DF3 CCCDD2              DB 0CCH,0CDH,0D2H
2DF6 D4DADC              DB 0D4H,0DAH,0DCH
2DF9 E2E4EA              DB 0E2H,0E4H,0EAH
2DFC ECF2F4              DB 0ECH,0F2H,0F4H
2DFF FAFC                DB 0FAH,0FCH
2E01           SSTRT:    DS 02H               ;SOURCE TOP(A)
2E03           SBOT:     DS 02H               ;SOURCE BOTTOM(B)
2E05           DTOP:     DS 02H               ;DESTINATION TOP(C)
2E07           START:    DS 02H               ;START OF REF. FIXING(D)
2E09           SSTP:     DS 02H               ;END OF REF. FIXING(E)
2E0B           FUNC:     DS 01H               ;00=REF. FIX ONLY (F)
                                              ;02=MOVE ONLY
                                              ;01=MOVE & FIX
2E0C           DISPL:    DS 02H               ;DISPLACEMENT
2E0E           STACK:    DS 08H               ;MEM. SPACE FOR STACK
```

Hexadecimal Code	Operator	Operand
AF	XRA	A
67	MOV	H,A
6F	MOV	L,A

Meanwhile, back in the real world, the LXI problem will usually be encountered by anyone relocating software. Going through a massive assembly listing and manually fixing references would be a tedious and time-consuming chore. Fortunately, the computer can be used to do the "grit" work.

A program that enables the computer to look through the machine code for LXI operation codes is presented in listing 2. I have called it FIXLXI, though corrections must still be made manually. However, the computer does the tedious job of finding LXI operation codes. Upon finding an LXI operation code, the computer outputs the address where the instruction is located, followed by the operation code (eg: 01 for LXI B), and finally the 2-byte hexadecimal constant that is loaded into the register pair. For compatibility with the terminal, all output is in the form of ASCII code. (The conversion from binary to ASCII is done by a simple table look-up procedure.)

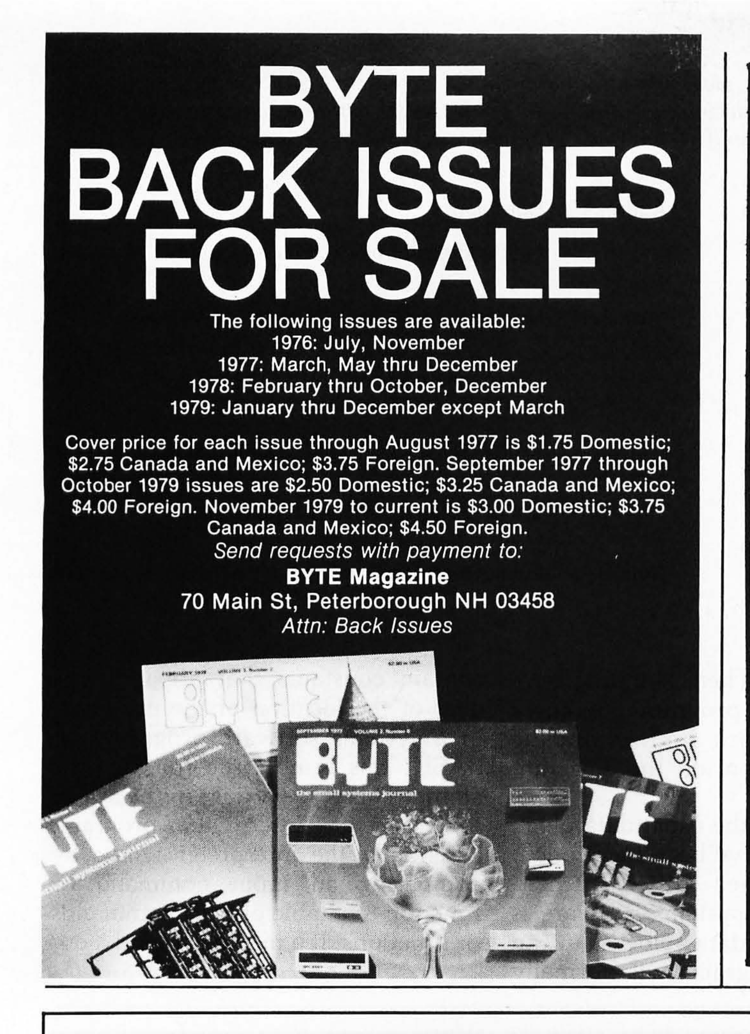
For example, upon finding the machine code equivalent of LXI D,21AEH at hexadecimal address 24AB, the program will cause output of the following:

24AB 11 21AE.

Afterward, control passes to the monitor and the operator consults the listing to verify that the code is correct. If not, a manual fix must be performed. (Using CP/M's Dynamic Debugging Tool program as a monitor makes this an easy task. Simply typing in S24AB to the terminal invokes a routine that displays both the memory address (24AB) and the memory contents (01) of the designated location. It then waits for a change to be entered, a command to look at the next memory location, or a command to quit.) When the program is reentered, the search for LXI operation codes resumes at the next operation code following the previously found LXI operation code.

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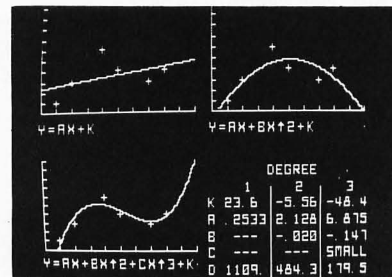
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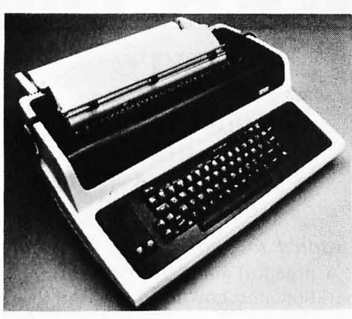
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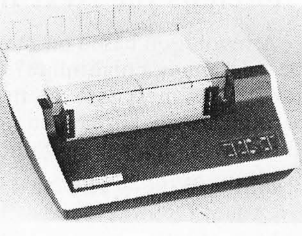
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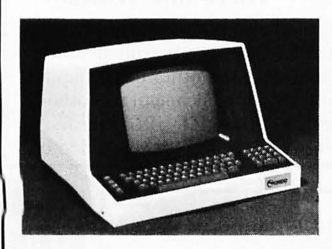


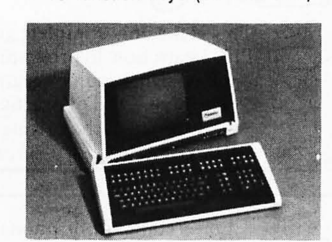
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specify the starting address (SSTAR) and the ending address (SSTP) of the code to be examined. In listing 2 this information is entered at hexadecimal addresses 2E42 and 2E44.

Employing the FIXLXI program with a terminal operating at a data rate of 1200 bits per second (bps), I found that I could get through our BASIC listing in less than two hours. Similar results were obtained when I relocated another old assembler program.

Data Block Problems

It is not good programming practice to place program constants in the midst of executable code. Unfortunately, this and other kludges are frequently found. However, you will find in most cases that the program constants are at least huddled together in a contiguous block. If this is true, the data block can be moved, but no fixing of references should be performed within the data block. As indicated by Zolman, the procedure in this case is to perform the fixing of references in two stages. First, program references are fixed in the program block up to, but not including, the data block. Then, skipping over the data block, program references after the data block are fixed for the remaining portion of the program block.

In addition to the usual data block problems that have been mentioned, there is another difficulty encountered when systems software is relocated. The data blocks in an applications program will normally contain constants that are independent of the location of the program. In a systems software program like BASIC this is *not* true for all constants. This is so because of the design logic of an interpreter program. Essentially the interpreter works by comparing an input command or function to a table of *legal* commands or functions. If a match is found, con-

Text continued on page 190

Table 1: *These six pieces of information must be entered into the locations shown (beginning at hexadecimal location 2E01 for listing 1) before a relocation can be performed with the modified relocator program.*

Label	Number of Bytes	Address	Comments
a	2	2E01, 2E02	First address of block to be relocated
b	2	2E03, 2E04	Last address of block to be relocated
c	2	2E05, 2E06	Destination address
d	2	2E07, 2E08	First address to have references fixed
e	2	2E09, 2E0A	Last address to have references fixed
f	1	2E0B	Function select: 00 = fix references only; 01 = move block and fix references; 02 = move block only

Listing 2: *An 8080 program to facilitate the examination and correction of load X immediate (LXI) instructions. (Because of the multiple uses of the LXI instruction, the relocator program of listing 1 can, in certain circumstances, mishandle the 2 bytes of information following the LXI code.) The program is designed to run with the Dynamic Debugging Tool (DDT) of the CP/M software. Given the starting and ending addresses of a source program block, this program finds LXI operation codes. It then displays the following information on the user's terminal: the memory address where the LXI instruction is located; the operation code; the 2 bytes following the operation code. Control is then passed to the monitor to allow the operator to make any needed corrections. Upon reentry the search for LXI operation codes is resumed at the next operation code following the LXI operation code previously found.*

```
2D00                        ORG    2D00H          ;SET ORIGIN
2D00 01182E       START:    LXI    B,TABL3        ;B,C=TABLE PTR
2D03 2A422E                 LHLD   SSTAR          ;D,E=MEMORY PTR.
2D06 EB                     XCHG
2D07 314E2E                 LXI    SP,STACK+8     ;INTIALIZE STACK
2D0A CDEB2D                 CALL   BUSY           ;CHECK CRT STATUS
2D0D 3E0A                   MVI    A,0AH          ;LINE FEED
2D0F D304                   OUT    CRT            ;TO CRT
2D11 CDEB2D                 CALL   BUSY           ;CHECK STATUS
2D14 3E0D                   MVI    A,0DH          ;CARR. RET
2D16 D304                   OUT    CRT            ;TO CRT
2D18 3A452E       CHEKF:    LDA    SSTP+1         ;CHECK FOR END OF FILE
2D1B 92                     SUB    D
2D1C C2262D                 JNZ    NEXT           ;CONTINUE IF NOT
2D1F 3A442E                 LDA    SSTP
2D22 93                     SUB    E
2D23 CA9D2D                 JZ     ENDF           ;QUIT IF END
2D26 1A           NEXT:     LDAX   D              ;LOAD MEM.CONTENTS USING PTR.
2D27 67                     MOV    H,A            ;SAVE IN H
2D28 AF                     XRA    A              ;ZERO ACCUM.
2D29 6F                     MOV    L,A            ;SET UP CNTR.
2D2A 2C           COMP3:    INR    L              ;BUMP CNTR
2D2B 7D                     MOV    A,L
2D2C FE1B                   CPI    27D            ;CHECK FOR END OF TABLE
2D2E CA3A2D                 JZ     AGAIN          ;JMP IF THRU
2D31 0A                     LDAX   B              ;LOAD TABLE ENTRY
2D32 94                     SUB    H              ;COMP. WITH CURR. MEM.
2D33 CA4F2D                 JZ     MTCH3          ;JMP IF MATCH
2D36 03                     INX    B              ;ELSE BUMP TABLE PTR.
2D37 C32A2D                 JMP    COMP3          ;LOOK AGAIN
2D3A 01062E       AGAIN:    LXI    B,TABL2        ;PTR HAS ADDR 2 BYTE OPS
2D3D AF                     XRA    A              ;ZERO ACCUM.
2D3E 6F                     MOV    L,A            ;SET CTR.
2D3F 2C           COMP2:    INR    L              ;BUMP CTR.
2D40 7D                     MOV    A,L
2D41 FE13                   CPI    19D            ;CHECK FOR END TABLE
2D43 CA572D                 JZ     NOMAT          ;JMP IF THRU
2D46 0A                     LDAX   B              ;LOAD TABLE ENTRY
2D47 94                     SUB    H              ;COMP. WITH CURRENT MEM.
2D48 CA562D                 JZ     MTCH2          ;JMP IF MATCH
2D4B 03                     INX    B              ;ELSE BUMP TABLE PTR.
2D4C C33F2D                 JMP    COMP2          ;LOOK AGAIN
2D4F 7D           MTCH3:    MOV    A,L            ;FOUND 3 BYTE OP CODE
2D50 FE05                   CPI    05D            ;LXI'S FIRST FOUR IN TABL3
2D52 DA5E2D                 JC     FDLXI          ;IF L<=4 OP IS LXI
2D55 13           NOLXI:    INX    D              ;NOT LXI IF HERE,SO
2D56 13           MTCH2:    INX    D              ;MOV MEM. PTR. TO NEXT LOC.
2D57 13           NOMAT:    INX    D
2D58 01182E                 LXI    B,TABL3        ;RESET TABLE PTR.
2D5B C3182D                 JMP    CHEKF          ;CONTINUE SEARCH
2D5E 7A           FDLXI:    MOV    A,D            ;FOUND LXI,PREP FOR OUT
2D5F CDAD2D       ADDR:     CALL   BYTE1          ;OUTPUT 1ST DIGIT:HI ADDR
2D62 7A                     MOV    A,D
2D63 CDB52D                 CALL   BYTE2          ;OUTPUT 2ND DIGIT:HI ADDR
2D66 7B                     MOV    A,E
2D67 CDAD2D                 CALL   BYTE1          ;OUTPUT 1ST DIGIT:LO ADDR
2D6A 7B                     MOV    A,E
2D6B CDB52D                 CALL   BYTE2          ;OUTPUT 2ND DIGIT:LO ADDR
2D6E CDDC2D                 CALL   SPACE          ;INSERT TWO SPACES
2D71 1A           OPCOD:    LDAX   D
2D72 CDAD2D                 CALL   BYTE1          ;OUTPUT OPCODE BYTES
2D75 1A                     LDAX   D              ;OF LXI INSTRUCTION
2D76 CDB52D                 CALL   BYTE2
2D79 CDDC2D                 CALL   SPACE          ;INSERT TWO SPACES
2D7C 13           CONST:    INX    D              ;D,E POINTS TO 16 BIT
2D7D 13                     INX    D              ;CONSTANT FOLLOWING LXI OP
2D7E 1A                     LDAX   D              ;LOAD IT IN ACCUM.
2D7F CDAD2D                 CALL   BYTE1          ;OUTPUT 1ST DIGIT OF CONSTANT
2D82 1A                     LDAX   D              ;LOAD AGAIN(BYTE1 CLOBBERS)
2D83 CDB52D                 CALL   BYTE2          ;OUTPUT 2ND DIGIT(ASCII CODE)
2D86 1B                     DCX    D              ;POINT TO 3RD&4TH DIGITS
2D87 1A                     LDAX   D              ;LOAD IN ACCUM.
2D88 CDAD2D                 CALL   BYTE1          ;OUTPUT 3RD DIGIT
2D8B 1A                     LDAX   D              ;LOAD AGAIN
2D8C CDB52D                 CALL   BYTE2          ;OUTPUT 4TH DIGIT
```

Listing 2 continued on page 190

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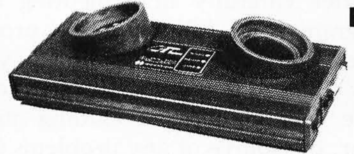
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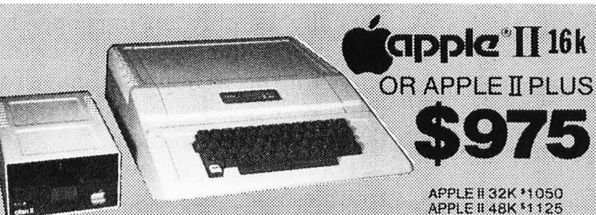
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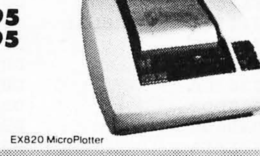
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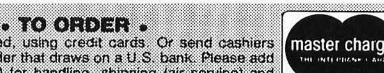
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Listing 2 continued:

```
2D8F CDDC2D             CALL   SPACE        ;INSERT TWO SPACES
2D92 13        THRU:    INX    D            ;ADVANCE MEM PTR
2D93 13                 INX    D            ;TO NEXT OP CODE
2D94 Ø1422E             LXI    B,SSTAR      ;SAVE MEM PTR
2D97 7B                 MOV    A,E          ;TO NEXT LOC.
2D98 Ø2                 STAX   B            ;SO CAN LOOK FOR
2D99 7A                 MOV    A,D          ;NEXT OP CODE
2D9A Ø3                 INX    B            ;UPON REENTRY
2D9B Ø2                 STAX   B            ;TO PROG.
2D9C FF                 RST    Ø7           ;GO MANUAL CONTROL
2D9D Ø1F12D    ENDF:    LXI    B,MESGE-1    ;FIND EOF MESSAGE
2DAØ Ø3        LOOPO:   INX    B            ;LOAD IT,BYTE AT A TIME
2DA1 CDEB2D             CALL   BUSY         ;CHECK STAT OF CRT
2DA4 ØA                 LDAX   B
2DA5 D3Ø4               OUT    CRT          ;PUT IT OUT
2DA7 FE48               CPI    'H'          ;TILL END
2DA9 C2AØ2D             JNZ    LOOPO        ;GO TO MANUAL
2DAC FF                 RST    Ø7           ;CONTROL WHEN FINIS
               ;*****   OUTPUT SUBROUTINES  *****
2DAD E6FØ      BYTE1:   ANI    ØFØH         ;MASK LEAST SIG. BITS
2DAF 47                 MOV    B,A          ;SAVE IT
2DBØ AF                 XRA    A            ;SET FLAG=Ø
2DB1 CDBE2D             CALL   OUTT         ;OUTPUT TO CRT
2DB4 C9                 RET                 ;RETURN FOR NEXT
2DB5 E6ØF      BYTE2:   ANI    ØFH          ;MASK MOST SIG. BITS
2DB7 47                 MOV    B,A          ;SAVE
2DB8 AF                 XRA    A            ;A=Ø
2DB9 3C                 INR    A            ;SET FLAG=1
2DBA CDBE2D             CALL   OUTT         ;OUTPUT TO CRT
2DBD C9                 RET                 ;MORE?
2DBE FEØØ      OUTT:    CPI    ØØH          ;CHECK FLAG
2DCØ C2CB2D             JNZ    RESTR        ;IF Ø1 BR AROUND
2DC3 78                 MOV    A,B          ;GET OUT BYTE
2DC4 1F                 RAR                 ;SHIFT INTO
2DC5 1F                 RAR                 ;LOWEST 4 BITS
2DC6 1F                 RAR                 ;PREP FOR CONV
2DC7 1F                 RAR                 ;TO ASCII
2DC8 C3CC2D             JMP    TYPOT        ;CONVERT & OUTPUT
2DCB 78        RESTR:   MOV    A,B          ;GET OUT BYTE
2DCC 6F        TYPOT:   MOV    L,A          ;SET UP FOR CONV
2DCD AF                 XRA    A
2DCE 67                 MOV    H,A          ;Ø IN TOP 8 BITS
2DCF Ø1322E             LXI    B,ASCTB      ;LOAD ADDR TABLE IN B,C
2DD2 Ø9                 DAD    B            ;GET POS IN TABLE
2DD3 EB                 XCHG                ;SAVE D,E
2DD4 CDEB2D             CALL   BUSY         ;CHECK STAT OF CRT
2DD7 1A                 LDAX   D            ;LOAD CONV. VALUE
2DD8 D3Ø4               OUT    CRT          ;PUT IT OUT
2DDA EB                 XCHG                ;GET D,E BACK
2DDB C9                 RET                 ;RETURN FOR NEXT BYTE
2DDC CDEB2D    SPACE:   CALL   BUSY         ;CHECK CRT STAT
2DDF 3E2Ø               MVI    A,' '        ;SPACE
2DE1 D3Ø4               OUT    CRT          ;TO CRT
2DE3 CDEB2D             CALL   BUSY         ;CHECK STAT
2DE6 3E2Ø               MVI    A,' '        ;ANOTHER SPACE
2DE8 D3Ø4               OUT    CRT          ;TO CRT
2DEA C9                 RET
               ;*****   STATUS CHECK OF OUTPUT PORT  *****
2DEB DBØ5      BUSY:    IN     CRTS         ;CHECK IF READY
2DED 1F                 RAR
2DEE D2EB2D             JNC    BUSY
2DF1 C9                 RET                 ;RETURN IF READY
2DF2 ØAØD      MESGE:   DB ØAH,ØDH
2DF4 454E44204F         DB 'END OF FILE SEARCH'
               ;*****   TABLES AND CONSTANTS  *****
2EØ6 Ø6ØE16    TABL2:   DB Ø6H,ØEH,16H      ;TABLE OF 2 BYTE
2EØ9 1E262E             DB 1EH,26H,2EH      ;OP CODES
2EØC 363EC6             DB 36H,3EH,ØC6H
2EØF CEDED6             DB ØCEH,ØDEH,ØD6H
2E12 DBDEE6             DB ØDBH,ØDEH,ØE6H
2E15 EEF6FE             DB ØEEH,ØF6H,ØFEH
2E18 Ø11121    TABL3:   DB Ø1H,11H,21H      ;TABLE OF 3 BYTE
2E1B 312A22             DB 31H,2AH,22H      ;OP CODES.
2E1E 323AC2             DB 32H,3AH,ØC2H     ;LXI INSTR. ARE FIRST
2E21 C3C4CA             DB ØC3H,ØC4H,ØCAH
2E24 CCCDD2             DB ØCCH,ØCDH,ØD2H
2E27 D4DADC             DB ØD4H,ØDAH,ØDCH
2E2A E2E4EA             DB ØE2H,ØE4H,ØEAH
2E2D ECF2F4             DB ØECH,ØF2H,ØF4H
2E3Ø FAFC               DB ØFAH,ØFCH
2E32 3Ø313233  ASCTB:   DB 3ØH,31H,32H,33H  ;TABLE OF ASCII
2E36 34353637           DB 34H,35H,36H,37H  ;EQUIVALENTS OF
2E3A 38394142           DB 38H,39H,41H,42H  ;NOS. 1-F HEX
2E3E 43444546           DB 43H,44H,45H,46H
2E42           SSTAR:   DS Ø2H              ;START OF SOURCE
2E44           SSTP:    DS Ø2H              ;END OF SOURCE
2E46           STACK:   DS Ø8H              ;SPACE FOR STACK
ØØØ4 =                  CRT EQU Ø4          ;CRT PORT
ØØØ5 =                  CRTS EQU Ø5         ;CRT STATUS PORT
```

Text continued:

trol is passed to that routine within the BASIC code. This procedure is frequently implemented by storing the address of the desired routine immediately adjacent to the command (function). (Actually, since commands (functions) are not all the same length (RESTORE is larger than FOR), it is common practice to place a delimiter, such as 0, immediately after the command (function). The address of the proper routine then follows.)

Thus, after the system software has been relocated and program references fixed, the command and function table addresses must also be fixed. These areas will usually be clearly indicated in the program listing. Also, since the data that must be changed is reasonably small, a manual fix can be readily performed. The success of this process is dependent upon your knowing the new addresses of the command (function) routines. Consequently, if a number of shifts and/or additions must be made, I would strongly suggest that changes and fixes be made one at a time. While this procedure requires more work, it is preferable to making all changes at once, since it is easy to lose track of where everything is located.

Caveat Emptor

After carefully implementing the programs and following the procedures that have been outlined, you may still find that your relocated software has glitches. Excluding pilot error, the source of any problems can logically be only an improper reference fix. While there may be many ways for this to happen, I have found only two species of software bugs that create this problem.

The first, and potentially least troublesome, bug occurs when an isolated byte or two of data is buried in the middle of executable code. With this particular gem I also found a call to a subroutine whose sole function was to implement a jump over the data! (I'm not making this up. I really did find this super kludge.)

If you are extremely lucky, the isolated byte(s) will not just happen to be the same as one of the 2- or 3-byte operation codes. In this case the relocator program will assume incorrectly that it is a 1-byte operation and correctly continue to search for 3-byte operation codes. In the more

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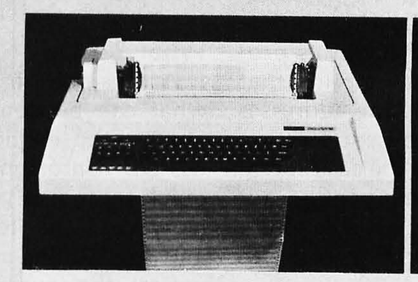
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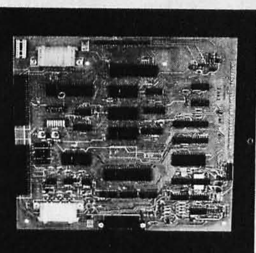
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usual case, the isolated byte will be identical to a 2- or 3-byte operation code. Then the possibility exists not only for an improper reference fix, but also for a mangling of the operation code(s). Fortunately, this mangling process is generally not self-propagating, so the damage is usually localized.

The second, and potentially most troublesome, bug involves the writing of relocatable code. While it may come as a surprise, yes there is such a thing as nonrelocatable code. To see that this is so, recall that the relocator program fixes references by operating only on the 2-byte hexadecimal constant following 3-byte operation codes. Implicit in this procedure is the logical assumption that all references to program addresses will be made via 3-byte operation codes. Certainly this is the easiest and most natural way to handle addresses. However, it is possible to use the 1- and 2-byte operation codes to manipulate addresses.

As a case study of this particular "buggy" (and bugging) practice, I submit the verbatim example from a listing of an assembler program in listing 3.

In this example the programmer needed to load the character following an operation code into the DE register pair without disturbing the HL register pair. Without a detailed knowledge of other program constraints, it is difficult to specify a foolproof fix for this code. Assuming no stack problems, appropriate substitutions are suggested in listing 4.

Those wishing to write relocatable code will avoid use of the programming practice illustrated in listing 3. (This is not an onerous requirement, since code that violates this convention tends to be tortured and unnatural.) Those who, for proprietary or other reasons, wish to write nonrelocatable code will liberally sprinkle their code with such examples.

What To Do

At this point it is reasonable to ask what can be done if you encounter one of the exotic bugs I have discussed. Unfortunately, there is no quick fix that is generally applicable. However, the following guidelines and suggestions may be helpful.

First, the source of the bug needs to be isolated to an area less than the size of the whole program. To do this, study the actual operation of the program. For which commands or functions does the program fail? After this bit of detective work, examination of the command or function table of your listing will tell you where to begin looking for the bug(s).

If nothing turns up at this point, the bug may be in a subroutine called by the command (function) routine. Even worse, it may be in a subroutine called by the subroutine, etc.

Finally, if all else fails, it will be necessary to perform a step-by-step trace of the operation of the program. At best this is a tedious process. If, however, you have isolated the bug, it is possible to set up a breakpoint that is activated only upon entry to the program segment that is suspect. (A breakpoint works by causing program control to pass to the monitor when the breakpoint is encountered. Before the breakpoint is activated, program execution is performed at normal machine speed.) With the Dynamic Debugging Tool program of the CP/M system distributed by IMSAI, a single breakpoint can be set by temporarily replacing a byte of the suspect software with the RST 07 instruction (FF in machine code). After the monitor has control, you can use it to generate a detailed trace of the program's operation for the suspect area.

After this recounting of the perils of relocating systems software, I hope that the reader is not totally discouraged. For well-designed software, relocation can be easily managed using the relocator and FIXLXI programs. ■

Address	Hexadecimal Code	Instruction Mnemonic	Operand	Commentary
BDC4	3E F0	MVI	A,ABUFF and 0FFH	;LOAD LOW BUFFER ADDRESS
BDC6	80	ADD	B	;ADD LENGTH OF OP CODE
BDC7	5F	MOV	E,A	
BDC8	3E D4	MVI	A,(ABUFF and 0FF00H)/256	
BDCA	CE 00	ACI	0	;GET HIGH ORDER ADDRESS
BDCC	57	MOV	D,A	
BDCD	1A	LDAX	D	;FETCH CHARACTER AFTER OP CODE

Listing 3: *An example of poor programming practice. In this example, the programmer has loaded the DE register pair without disturbing the HL register pair. However, because the reference to the address hexadecimal D4F0 is done via 1 and 2-byte op code, this machine is not machine relocatable.*

Address	Hexadecimal Code	Instruction Mnemonic	Operand	Commentary
BDC4	11 F0 D4	LXI	D,D4F0	;LOAD BUFFER ADDRESS
BDC7	E5	PUSH	H	;SAVE H,L PAIR
BDC8	68	MOV	L,B	;GET LENGTH OP CODE
BDC9	26 00	MVI	H,00	;PAD WITH ZEROS
BDCB	19	DAD	D	;ADD LENGTH TO BUFFER
BDCC	EB	XCHG		;PUT RESULTS IN D,E
BDCD	E1	POP	H	;GET H,L BACK
BDCE	1A	LDAX	D	;FETCH CHARACTER AFTER OP CODE

Listing 4: *Another method of performing the operation shown in listing 3. Here the reference to the address hexadecimal D4F0 is done using the LXI op code. This code is machine relocatable.*

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The purpose of this club is to trade ideas, data, and programs related to the stock, option, and commodity markets. Club projects include the development of computerized trading and investment systems, and the development of a shared data base.

Write to Computerized Investments Club, R D 1 Box 138, Sicklerville NJ 08081.

Videodisc News

This monthly newsletter is designed for readers in communications, education, television, audio and visual production, information storage and retrieval, microcomputers, and home video entertainment. Articles will cover new developments in software and hardware, competitive comparisons, conferences and services, and more. A special subscription rate of $95 per year is available to BYTE readers.

Contact Subscriber Services, *Videodisc News*, POB 5340, W Bloomfield MI 48033.

Medical Computer Journal

MCJ is a newsletter that is devoted to information about computers and their uses in the daily practice of private physicians. Issues will cover the most common illnesses and the use of computers in dealing with them, computer systems, laboratory test interpretation and analysis using computers, and ideas for the uses of computers in offices.

Subscriptions are $15 per year. For information, contact Dr Aziz Ghaussy, editor of the *MCJ*, 42 E High St, E Hampton CT 06424.

Computer Newsletter for Engineers

Engineering Computer Applications Newsletter (ECAN) is being published monthly to inform and advise engineers on how to use advanced computer technology and increase productivity and profits. *ECAN* will contain articles on small

computers, peripheral equipment, engineering programs, combining large and small computers, graphics in engineering design, and many other topics. Subscriptions are $36 per year. Contact *ECAN*, 5 Denver Tech Ctr, POB 3109, Englewood CO 80111.

Crescent City Computer Club

This club meets once a month in a general meeting and they also have monthly meetings for their specialized groups. Their meetings are held at 8 PM in room 2120 of the University of New Orleans Science Bldg, on the main campus. The club also publishes a newsletter that covers the events of the meetings.

Contact the Crescent City Computer Club, POB 1097, University of New Orleans LA 70122.

Arcadian Newsletter

This newsletter has articles concerning various aspects of computing. Programs, schedules of events, corrections of programs, and general information items appear. Ads are welcome, and the latest issue included an item from the editor looking for reviews of software programs.

Contact *Arcadian*, 3626 Morrie Dr, San Jose CA 95127.

Apple Canada Users Group

This new group has been meeting on the first Wednesday of every month at the Computerland/Toronto store, 2180 Yonge St, Toronto, Ontario Canada. The meetings begin at 7:30 PM.

Contact Apple-Can, 2180 Yonge St, Toronto, Ontario M4S 2B9 CANADA.

Heath Users Group (HUG) Newsletter

REMark is a HUG membership magazine published quarterly for members only. The newsletter contains articles on programming, expanding the capabilities of Heath computers and items of general interest. Subscriptions are $14 a year and should be sent to the Heath Users' Group, Hilltop Rd, St Joseph MI 49085.

Sphere Newsletter

The Sphere Microcomputer Newsletter contains hardware and software features of interest to M6800 microcomputer owners and more specifically to Sphere owners. The newsletter is mailed 6 times a year. The subscription rate is $12 and should be addressed to Jeffrey Brownstein, 2 Tor Rd, Wappingers NY 12590. Material for publication should be sent to coeditor Roger J Spott, 13975 Connecticut Ave, Wheaton MD 20906.■

BYTE's Bugs

Like All Modern Vehicles — The Cost Goes Up

George, the programmable toy van from Beneficial Marketing, was listed in the November issue as costing $24.95. This should read $39.95.■

BYTE's Bits

A New System for Medical Data Processing

The Computer Center Inc, 433 Valley Ave, Birmingham AL 35209, is marketing the Doctors Office Computer System (DOCS). DOCS organizes precise methods to control cash flow and has the capability to handle all doctors' medical and financial bookkeeping needs in a single system. The present package processes charge and payment entry, patient statements, insurance billing, Medicare and Medicaid submittals, collection agency referrals, and the patient accounting system identifies unpaid charges by age, amount, and percentage of payment. Additionally, the patient accounting system handles patient admission updates, records, and appointments.

DOCS is designed to run on an Alpha Micro 100, with a minimum of 64 K memory and is currently being adapted for use on Texas Instruments and Hewlett-Packard systems. To install DOCS, a medical group can expect to invest from $35,000 to $70,000 for hardware and software.

Call for Papers

On August 27-28, the IEEE Computer Society will sponsor the Second Workshop on Picture Data Description and Management in Asilomar, California. This conference will address the problems of storage, retrieval and manipulation of pictures of great complexity and of large numbers of pictures. Papers on pictorial information systems, applications of pictorial data bases, picture syntax and semantics, combinatorial problems in image data structures, data structures for image data mangement, computer graphics of complex images and animation, image stores, computer architecture for picture processing, and other topics are being solicited. To submit papers, please send four copies to Professor S K Chang, Program Chairman, 1980 PDDM Workshop, Dept of Information Engineering, University of Illinois at Chicago Circle, POB 4348, Chicago IL 60680.

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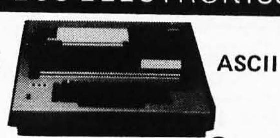
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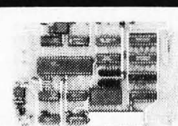
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Computer Chess Competition

Chess 4.9, the program written by David Slate and Larry Atkin of Northwestern University, regained the title of North American Computer Chess Champion in the tournament held during the convention of the Association for Computing Machinery (ACM) in Detroit, Michigan from October 28 to October 31, 1979.

Slate and Atkin's program (then called Chess 4.7) was upset in the 1978 championship by the program Belle, written by Ken Thompson of Bell Laboratories. Belle won the 1978 competition with a perfect score of four wins in the 4-round Swiss System tournament. (See "Computer Chess Report," May 1979 BYTE, page 174.)

In the 1979 Tenth Annual North American Computer Chess Championship, however, Belle suffered a setback in the third round of competition when the Chaos program (written by Mike Alexander, Fred Swartz, John O'Keefe, and Victor Berman of the University of Michigan) fought Belle to a draw. The hopes of Belle's backers were further dashed when Chess 4.9 also achieved a draw with Belle in the fourth and final round. With this final half-point, Chess 4.9 wrested a clear-cut victory in the tournament with a score of 3½ out of 4 possible points.

Player \ Opponent	Chess 4.9	Belle	Duchess	Chaos	L'excentrique	Mychess	Blitz 6.9	Sargon 2.5	Ostrich 80	Awit	BS '66 '76	Rufus	Score
Chess 4.9		½	1				1		1				3½
Belle	½			½	1			1					3
Duchess	0			1				1		1			3
Chaos		½	0				1					1	2½
L'excentrique		0				½			1			1	2½
Mychess					½			0		1	1		2½
Blitz 6.9	0			0				½			1		1½
Sargon 2.5		0	0			1	½						1½
Ostrich 80	0				0					½	1		1½
Awit			0			0			½			1	1½
BS '66 '76						0	0		0			1	1
Rufus				0	0					0	0		0

Table 1: *Cross-table of the results of games in the Tenth Annual North American Computer Chess Championship, held October 28 to October 31, 1979 in Detroit, Michigan. The table contains blank entries, since each program did not play every other program in the 4-round Swiss System event.*

Three programs of the twelve competing in the event were run on microcomputer systems. The program Mychess, written in Z80 assembler language by David Kittinger of Anchorage, Alaska, ran on a Cromemco Z-2D system with 64 K bytes of memory and gained a score of 2½ points. Dan and Kathe Spracklen entered version 2.5 of Sargon, which ran on a 6502-based electronic chessboard processor; the program obtained a score of 1½ points. The program Rufus, written by Charles Sullivan in 6502 assembler, did not fare so well. It lost all games and ended with a score of zero. Rufus ran on an Apple II computer in 48 K bytes of memory.

Besides these three programs that used microprocessors to calculate what moves to make, two programs that ran on large computers employed microprocessors to control electronic chessboards that indicate moves with light-emitting diodes and transmit opponent's moves automatically. Both Chess 4.9 and Blitz 6.9 (written by Robert Hyatt and Albert Gower of the University of Sourthern Mississippi) used these devices.

The tournament was organized by a committee comprising Monroe Newborn, Ben Mittman, Ira Purchis, and David Dahm. The tournament director was International Master David Levy (who was featured in "Chess 4.7 versus David Levy," by J R Douglas, December 1978 BYTE, page 84). In attendance as observers were one-time World Champion Max Euwe (oy - vuh), president of the Federation Internationale des Echecs (FIDE), and George Koltanowski, former presi-

dent of the United States Chess Federation (USCF) and noted player of blindfold chess.

Stanford University professor John McCarthy presented the tournament awards and spoke at a ceremonial luncheon held on the final day of the ACM convention.

A cross-table of game results achieved by the twelve programs is reproduced here in table 1. According to Dr Newborn, the strength of play of all the programs in the 1979 competition was greater than in the previous tournaments.

An interesting experiment took place on the Saturday preceding the tournament. David Levy, with an ability rating of about 2390, played a single game against a team consisting of David Slate (USCF rating of about 2050) and his program, Chess 4.9 (also rated at about 2050). The purpose was to find out if cooperation between man and machine could produce better play than either man or machine playing alone.

According to rating statistics, a player rated 2050 should, in a 20-game match, win perhaps two games and draw perhaps five. It was expected that the Slate-Chess 4.9 team would have an effective rating of about 2150, with Levy favored to win.

True to expectation, Levy used his knowledge of the strong and weak areas of the opposing team and won the game. Nevertheless, development of the symbiotic relationship between the human player and a computer may yet extend the capabilities of both men and machines.

Microcomputers in Education

A nonthreatening first experience with microcomputers for kindergarten to 12th grade teachers has been developed by Dan Isaacson at the University of Oregon. He designed a self-instructional, laboratory-type course to help teachers use computers without having to be programmers.

The course consists of programs and text that show how to turn on the computer, load programs, explore materials at various levels in fine arts, business, English, foreign languages, consumer economics, and more. The program will be released in the summer of 1980 for use by public schools and colleges of Education. For more information, contact Dan Isaacson, Computer Center, University of Oregon, Eugene OR 97403.■

BYTE's Bugs

Reformatting Dollars and Cents

Mr J R Borden of Laguna Hills CA, has pointed out an error in my recent letter on formatting dollars and cents ("Good Cents," September 1979 BYTE, page 150). In trying to compact the procedure to one line, I erred in the roundoff, the results not being correct for $1.995 and similar cases. A correct version is given in line 30 of the adjacent listing.

```
20 IF X < 0 THEN X = ABS
   (X): PRINT "—";
30 X = X + 0.005: PRINT
   "$"; INT (X);".";RIGHT$ (
   STR$ ( INT (100 * (X +
   1))),2)
```

Mr Borden also considered the case of negative quantities. To handle these requires an additional line, line 20 in the listing.

I apologize for any inconvenience this error may have caused.

James D Childress
5108 Springlake Way
Baltimore MD 21212 ■

Event Queue

In order to gain optimum coverage of your organization's computer conferences, seminars, workshops, courses, etc, notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, 70 Main St, Peterborough NH 03458. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

JANUARY 1980

Education Coordinators' Workshops 1980. Held throughout 1980, these workshops will cover costing, justifying costs, course design strategies, scheduling, record keeping and reporting to management. For information on when and where the workshops will be held, write to Deltak Inc, 1220 Kensington Rd, Oak Brook IL 60521, or call (312) 920-0700.

January 3-4

Hawaii International Conference on System Sciences, Honolulu HI. The conference will cover developments in theory and practice in software and hardware, and advanced computer systems applications in selected areas, with emphasis on medical information processing and computer-based decision support-systems for upper level managers in organizations. For more information, contact Perry G Patteson, Office of Management Programs, University of Hawaii, 2404 Maile Way, Honolulu HI 96822.

January 5-8

International Winter Consumer Electronics Show, Las Vegas Convention Center, Grand Ballroom of the Las Vegas Hilton and the Jockey Club Hotel, Las Vegas NV. The show will have over 850 exhibitors covering markets including audio systems, software, television and video tape and disk systems, home computers, calculators, and many more. Contact Consumer Electronics Shows, 2 Illinois Center, Suite 1607, 233 N Michigan, Chicago IL 60601.

January 5 and 12

Introduction to Computing and Personal Computers, Human Computing Resources, 10 St Mary St, Toronto Ontario M4Y 1P9 CANADA. This course will cover introductions to computers, programming, software and hardware, using computers in homes and offices, and buying and owning a personal computer.

January 8-24

Tuesdays and Thursdays, **Introductory Programming in BASIC,** Human Computing Resources, 10 St Mary St, Toronto Ontario M4Y 1P9 CANADA. Direct execution of commands, the writing of simple BASIC programs, system dialects, error handling and debugging, and programming methods and style will be covered in this course.

January 15

Invitational Computer Conference, Orange County CA. New developments in computer and peripheral technology such as Pascal systems, printers, and streaming tape drives will be featured in this conference directed to the quantity buyer. For more information, contact B J Johnson and Associates, 2503 Eastbluff Dr, Suite 203, Newport Beach CA 92660.

January 15-18

TV-Microelectronics and Microprocessing Exhibition, National Exhibition Centre, Birmingham, England. Manufacturers and suppliers of microprocessors, electronic and microcomputer games, video display units, video cameras and projection systems and digital consumer electronics are invited to participate. Over 9000 retailers, wholesalers, distributors and government buying authorities are expected to attend this show. For more information, contact TMAC, 680 Beach, Suite 428, San Francisco CA 94109.

January 17

Electronic Road Shows, Proud Bird Restaurant, Los Angeles Airport, Los Angeles CA. This traveling exhibition of components, materials and instruments is being produced by the Electronic Representatives Association (ERA). Over 80 ERA member firms will participate, and products from over 700 electronic companies will be displayed. For more information, contact the Southern California ERA office, 20969 Ventura Blvd, Suite 9, Woodland Hills CA 91364.

January 21-24

American Association of Physics Teachers and the American Physical Society, Chicago Marriott Hotel, Chicago IL. An introduction to microprocessors, a Pascal programming workshop, and a course on the use of personal computers in learning physics, plus more sessions on microprocessors will be presented.

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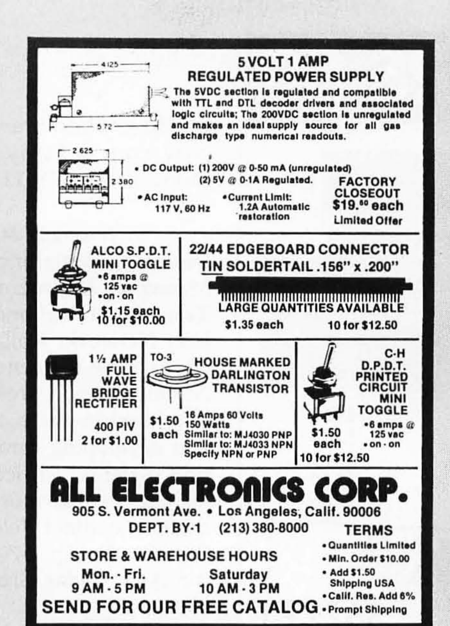
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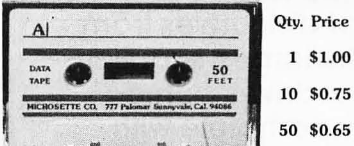
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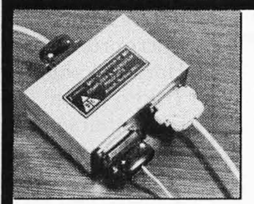


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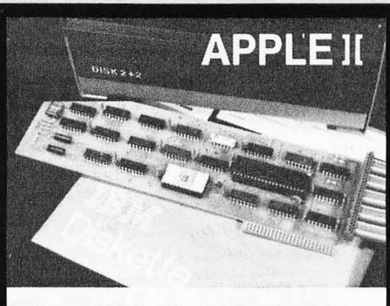
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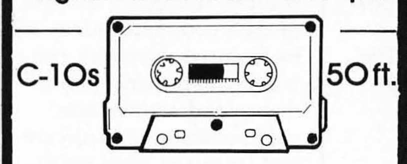
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January 22-24

Designing, Installing and Managing An International Telecommunications Private User Network, Dallas TX. This course is intended for communication professionals interested in understanding and developing communication systems, services, and techniques. For more information, contact Telecom Systems Group, 579 Pompton Ave, Cedar Grove NJ 07009.

January 23-26

International Microcomputers Minicomputers Microprocessors (IMMM), Harumi Exhibition Centre, Tokyo Japan. This is a show for manufacturers, commercial and financial establishments, service industries and institutions, and design engineers interested in buying computer systems, components and services. For more information, contact Industrial and Scientific Conference Management Inc, 222 W Adams St, Chicago IL 60606.

January 28-30

Communication Networks '80, Sheraton Washington Hotel, Washington DC. The program will offer 50 conference sessions in areas such as fiber optics, satellite communications, systems networks, and innovations in electronic mail and office administrative networks.

For further information on registration, speaking opportunities or exhibit space, contact William Leitch, The Conference Company, 60 Austin St, Newton MA 02160.

January 28-30

Principles of Programming Languages, Las Vegas NV. This symposium concerns practical and theoretical aspects of principles and innovations in the design, definition, and implementation of programming languages. Some topics are algorithms and complexity bounds for language processing tasks, specification languages, error detection and recovery, and unusual or special-purpose languages that raise issues of principle. Contact Professor John Werth, Dept of Mathematical Sciences, University of Nevada, Las Vegas NV 89154.

January 30-February 1

MIMI'80 Asilomar, Asilomar Conference Grounds, Pacific Grove CA. This symposium covers all aspects of mini and microcomputers including technology, hardware, software engineering, languages, education and more. Contact The Secretary, MIMI '80 Asilomar, POB 2481, Anaheim CA 92804.

FEBRUARY 1980

February 6

Invitational Computer Conference, Ft Lauderdale FL. This conference is directed to the quantity buyer and will feature the newest developments in computer and peripheral technology. Contact B J Johnson and Associates, 2503 Eastbluff Dr, Suite 203, Newport Beach CA 92660.

February 12-14

Data Communications Conference and Exhibition, Harbour Castle Hilton, Toronto Ontario, Canada. Panel sessions, presentations, workshops, and technical sessions related to the field of data communications will be featured. Network control, management, performance and architecture; communications hardware and software; fiber optics; distributed data processing; and international communications policies are some of the subject areas that will be discussed.

The exhibition at the convention center will feature over 100 exhibitors.

For more information, contact Whitsed Publishing

Ltd, Suite 2504, 2 Bloor St W, Toronto Ontario M4W 3E2 CANADA.

February 13-15

The IEEE International Solid State Circuits Conference, San Francisco CA. This conference is a forum for the presentation of advancements in all aspects of solid state circuits. It will cover design, performance, fabrication, testing, and applications in digital, analog, microwave, and other areas of new solid state circuits, device structures, phenomena and systems. For more information, contact Lewis Winner, 301 Almeria Ave, POB 343788, Coral Gables FL 33134.

February 18-21

European Information Management Exhibition and Conference, Wembley Conference Centre, London England. This show will exhibit microcomputer systems and peripheral items with demonstrations and applications focused on problem solving for the management executive. Contact, Expoconsul, 420 Lexington Ave, New York NY 10017.

February 22-23

Louisiana Computer Exposition, University of Southwestern Louisiana, Lafayette LA. This conference is entitled "Distributed Systems Based on Mini and Micro Computers." It will cover programming languages, operating systems, evaluation of distributed systems, design criteria for distributed systems, and other related topics. There will be exhibitions of equipment and papers will be read and discussed. For more information, contact the Computer Science Dept, University of Southwestern Louisiana, POB 44330, Lafayette LA 70504.

February 25-27

Communication Networks '80, Shoreham Americana Hotel, Washington DC. This conference and exposition will cover business communications. For program information, contact the Director of Program Development, The Conference Company, 60 Austin St, Newton MA 02160. For exhibit information, contact the national sales manager, Communications Networks '80, POB 96, Haddon Heights NJ 08035.

February 25-28

Compcon 80, Jack Tar Hotel, San Francisco CA. The conference theme is "VLSI: New Architecture Horizons." It will be devoted to developing advanced technologies for computers. Contact Compcon Spring '80, POB 639, Silver Spring MD 20901.

February 26-28

Nepcon West '80, Anaheim Convention Center, Anaheim CA. The conference and exhibit will deal with the latest advances in electronics by covering such topics as wave soldering, etching, automated assembly, die attaching, hybrid circuit packaging, photo lithography, precious metal recovery, laser annealing, and much more. For further information, contact ISCM Inc, 222 W Adams St, Chicago IL 60606.

February 26-29

Office/Korea/80, Korea Exhibition Center, Seoul Korea. Exhibits at this exposition will include the range of products needed in offices from computers, word processing equipment and software to stationary, supplies, furniture and services. Information about the show may be obtained from Expoconsul, a division of Clapp and Poliak, 420 Lexington Ave, New York NY 10017.

MARCH 1980

March 3-5

Office Automation Conference, Georgia World

Congress Center, Atlanta GA. A combination conference and exhibition of office computer systems has been developed to help management understand the growing technology of business computer systems. For more information, contact H A Bruno and Associates Inc, 78 E 56th St, New York NY 10022.

March 10-12

1980 National Office Exhibition and Conference, Automotive Building, Exhibition Pl, Toronto Canada. Subject areas of the conference will include energy conservation, small business computers, micrographics, word processing, telecommunications, copiers, office landscaping, and many others. There will be approximately 100 exhibitors presenting their products and giving demonstrations.

For more information, contact Whitsed Publishing Ltd, Suite 2504, 2 Bloor St W, Toronto Ontario M4W 3E2 CANADA.

March 14-16

West Coast Computer Faire, Civic Auditorium and Brooks Hall, San Francisco CA. An expected 15,000 attendees, over 340 exhibits, and more than 100 conference speakers will highlight this year's program. Exhibitor and speaker information may be requested from the Computer Faire, 333 Swett Rd, Woodside CA 94062.

March 17-20

Interface '80, Miami Beach Convention Center, Miami Beach FL. This conference and exposition is devoted to data communications, distributed data processing, and networking. Approximately 1000 exhibitors are expected and attendance is expected to exceed 12,000. For information, contact Interface '80, 160 Speen St, Framingham MA 01701.

March 17-21

Applied Time Series Analysis, University of California at Los Angeles CA. This course is designed for engineers, scientists, programmers, economists and other users of digital time series who require modern methods of data analysis using the fast Fourier transform, digital filtering, power spectral densities and correlation functions. The lectures cover topics relating to the Fourier transform, sampling linear systems, convolution, covariance, digital filtering, power and cross-spectral density functions, and introductions to new methods in spectral analysis and rotating machinery analysis. For more information, contact UCLA Extension, 10995 Le Conte Ave, Los Angeles CA 90024.

March 20

Electronic Road Shows, Castaways Restaurant, Burbank CA. See January 17 for details.

March 24-28

Fourth European Conference on Electrotechnics, Stuttgart. This conference will review recent development trends and applications in the field of microelectronics. Microprocessors, computer communication, industrial electronics applications of microelectronics in the automobile and in medicine, and other topics will be covered. The conference language will be English. Contact Professor Dr W E Proebster, IBM Deutschland GmbH, Postfach 80 08 80, D-7000 Stuttgart 80 GERMANY (BRD).

March 26-28

Viewdata '80, Wembley Conference Centre, London England. Viewdata 80 is an international exhibition and conference on video-based systems and microcomputer industries. The British Post Office is presenting the Prestel Show, about electronic mail services.

Contact TMAC, 680 Beach St, Suite 428, San Francisco CA 94109. ■

A French-English/ English-French Dictionary

Dr Fred Levit, 251 E Chicago Ave, Chicago IL 60611

The program FRENGLSH turns a microcomputer into a foreign language dictionary. As written here, it will look up the French or English word entered and then print the translation. It does not translate phrases or sentences, but serves as a replacement for a paper dictionary.

FRENGLSH is written in CBASIC and uses two files which are stored on a disk. The first file, called DICTION, is a random access file each record of which contains pairs of words with the pairs separated by slashes. Each pair of words consists of a French word followed by a dollar sign and then the corresponding English word, or an English word followed by a colon and then the corresponding French word. As you can see in table 1, the word pairs are arranged in the record alphabetically by the left-hand word of each pair.

The second file used by FRENGLSH is called FRINDEX and is an index to the diction file. It contains a list of the first words in each record of the DICTION file, arranged alphabetically, with the corresponding line number in the DICTION file where that word is found. This file is read into an array in memory so that it can be searched rapidly when the program is running.

When a word is entered, FRENGLSH first searches the index to find the line number in DICTION where the wanted word pair will be found (lines 70 to 97 of listing 1). It then goes to that line in the file and searches the record for the wanted word plus the correct separator. Searching for the word with the separator appended avoids problems caused by similarly spelled words with different meanings which may be shared by French and English. When the correct left-hand member of the word pair has been found then the right-hand member of the pair is extracted (lines 99 thru 108, listing 1) and the entered word and its translation are printed.(See listing 2.)

The DICTION file contains about 1100 French words, which includes those most commonly used and needed by someone studying the language. Naturally not every word one might seek can be found, but, before giving up, FRENGLSH does one more thing. The infinitive form of most French verbs ends in -er or -oir, and that is the way the verbs are listed in a dictionary. But many verbs are most frequently encountered in the second person form,

Table 1: *A portion of the file DICTION. Each record of 240 characters or less occupies about two and a half lines. Note that the words are in pairs, either French$English or English:French. The list is alphabetized by the left-hand word in each pair.*

```
''/A$TO/ABORD$APPROACH/ABOVE:AU-DESSUS(V)/ABOVE
ALL:SURTOUT/ABSENCE:ABSENCE(LA)/ABSENCE$ABSENCE/
ABSENT:ABSENT/ABSENT$ABSENT/ABSOLUMENT$ABSOLUTELY/
ABSOLUTELY:ABSOLUMENT/ACCEPT:ACCEPTER/''
''/ACCEPTER$ACCEPT(TO)/ACCIDENT$ACCIDENT/ACCIDENT:
ACCIDENT(LE)/ACCORD$AGREEMENT/ACCOUNT:COMPTE(LE)/
ACE:AS(LE)/ACHAT$PURCHASE/ACHETER$BUY(TO)/ACHEVER$
FINISH(TO)/ACIER$STEEL/ACQUAINTANCE:CONNAISSANCE(LA)/''
''/ACQUERIR$ACQUIRE/ACQUIRE:ACQUERIR/ACROSS:
TRAVERS/ACT:AGIR/ACTIF$ACTIVE/ACTION$ACTION OR
STOCK/ACTION:ACTION/ACTIVE:ACTIF/ACTUEL$PRESENT
TIME/ADD:AJOUTER/ADDITION$CHECK(RESTAURANT)/''
''/ADDITIONAL:ADDITIONNEL/ADDITIONNEL$ADDITIONAL/
ADDRESSER$ADDRESS(TO)/ADIEU$GOODBYE/ADMETTRE$
ADMIT(TO)/ADMIT:ADMETTRE/ADRESS:ADRESSE(LA)/ADRESSE$
ADRESS/ADULT:ADULTE(LE)/ADULTE$ADULT/''
''/ADVANCE(TO):AVANCER/ADVANTAGE:AVANTAGE(LE)/
ADVENIR$HAPPEN(TO)/ADVENTURE:AVENTURE(LA)/
ADVERTISEMENT:ANNONCE(LA)/AFFAIRE$BUSINESS/AFIN$SO
THAT/AFRICA:AFRIQUE(LA)/AFFIQUE$AFRICA/AFTER:APRES/''
''/AFTERNOON:APRES-MIDI(LE)/AFTERWARDS:ENSUITE/
AGAINST:CONTRE/AGIR$ACT(TO)/AGREEMENT:ACCORD(LE)/
AIDE$HELP/AIDER$HELP(TO)/AILLEURS$ELSEWHERE/AIMABLE$
AMIABLE/AIMER$LIKE OR LOVE/AINSI$SO/AIR$AIR/''
''/AIR:A
B>
```

Listing 1: *A listing of FRENGLSH. The program is written in CBASIC so that the line numbers at the left are not referenced by GOTO statements. Instead statement numbers are added by the programmer for statements which must be returned to. For example, line 61: GOTO 75 sends the program to line 48, which is statement 75.*

```
 1:  REM        PROGRAM FRENGLSH IS COPYRIGHTED (1978) BY
 2:  REM        THE AUTHOR, FRED LEVIT M.D., AND ALL RIGHTS
 3:  REM        ARE RESERVED.
 4:
 5:        DIM WORD$(188),LINE.NUM(189)
 6:        PRINT "V 1.0"
 7:        PRINT "JUL 78"
 8:
 9:        PRINT:PRINT:PRINT
10:
11:
12:        PRINT TAB(30);"PROGRAM FRENGLSH"
13:        PRINT
14:        PRINT  TAB(22);"A FRENCH-ENGLISH-FRENCH DICTIONARY"
15:
16:
17:        PRINT:PRINT
18:        PRINT "STARTING MODE IS FRENCH-ENGLISH. TO REVERSE MODE"
19:        PRINT "ENTER A 1 INSTEAD OF A WORD"
20:        PRINT
21:        PRINT"TO END THE PROGRAM ENTER A 9 INSTEAD OF A WORD"
22:        PRINT:PRINT
23:        PRINT "PLEASE WAIT 40 SECONDS WHILE WE LOAD"
24:
25:        PRINT:PRINT
26:
27:
28:        OPEN "DICTION" RECL 204 AS 2
29:        MODE$="F"
30:
31:  REM              READ INDEX INTO MEMORY
32:        OPEN "FRINDEX" RECL 25 AS 1
33:        IF END #1 THEN 50
34:
35:        N=1
36:        WHILE -1
37:           READ #1,N;WORD$(N),LINE.NUM(N)
38:           N=N+1
39:        WEND
40:
41:     50 CLOSE 1
42:
43:        PRINT "ENTER FRENCH WORD AFTER FR=  OR ENGLISH AFTER EN= "
44:        PRINT:PRINT
45:
46:  REM               ENTER WORD TO BE SOUGHT
47:
48:    75  PRINT:PRINT
49:        IF MODE$="F" THEN SEPARATOR$="$" ELSE SEPARATOR$=":"
50:             IF MODE$="F" THEN PRINT "FR= "; ELSE PRINT "EN= ";
51:
52:        INPUT ENTERED.WORD$
53:     85 WORD.SOUGHT$=ENTERED.WORD$
54:
55:        IF WORD.SOUGHT$="9" THEN STOP
56:        IF WORD.SOUGHT$="1" AND MODE$="F" THEN\
57:           MODE$ ="E":\
58:           GO TO 75
59:        IF WORD.SOUGHT$="1" AND MODE$="E" THEN\
60:           MODE$="F":\
61:           GO TO 75
62:
63:
64:  REM    PAD WORD.SOUGHT$ TO 15 CHARACTERS
65:
66:        WHILE LEN(WORD.SOUGHT$)-15
```

Listing 1 continued on page 208

Listing 1 continued:

```
67:            WORD.SOUGHT$=WORD.SOUGHT$+" "
68:         WEND
69:
70:  REM                BEGIN SEARCH OF INDEX
71:
72:         TOP.LINE = 1
73:         BOTTOM.LINE = N-1
74:
75:   100   MIDLINE = INT((BOTTOM.LINE-TOP.LINE)/2)+TOP.LINE
76:
77:
78:         IF WORD.SOUGHT$ = WORD$(MIDLINE)\
79:            THEN LINE.SOUGHT=MIDLINE:\
80:            GO TO 500
81:
82:         IF WORD.SOUGHT$ LT WORD$(MIDLINE)\
83:            THEN BOTTOM.LINE=MIDLINE
84:
85:         IF WORD.SOUGHT$ GT WORD$(MIDLINE)\
86:            THEN TOP.LINE=MIDLINE
87:
88:         IF BOTTOM.LINE-TOP.LINE NE 1 THEN\
89:            GO TO 100
90:
91:         IF WORD.SOUGHT$ LT WORD$(BOTTOM.LINE)\
92:            THEN LINE.SOUGHT=TOP.LINE:\
93:            GO TO 500
94:
95:         IF WORD.SOUGHT$ GE WORD$(BOTTOM.LINE)\
96:            THEN LINE.SOUGHT=BOTTOM.LINE:\
97:            GO TO 500
98:
99:  REM             MATCH FOR WORD NEEDED
100:
101:  500   READ #2,LINE.SOUGHT;A$
102:
103:         LOC1= MATCH(ENTERED.WORD$+SEPARATOR$,A$,1)
104:        IF LOC1 = 0 THEN GO TO 1000
105:         LOC2=MATCH("/",A$,LOC1)
106:         LOC3= MATCH(SEPARATOR$,A$,LOC1)
107:
108:        TRANSLATED$=MID$(A$,LOC3+1,LOC2-(LOC3+1))
109:
110:  REM        PRINT TRANSLATED WORD
111:
112:        PRINT ENTERED.WORD$;" = ";TRANSLATED$
113:        GO TO 75
114:
115:
116:  REM        WORD NOT FOUND.  CHECK FOR VERB ENDING
117:
118:   1000 PRINT ENTERED.WORD$;" NOT FOUND.  ";
119:        IF RIGHT$(ENTERED.WORD$,2) ="EZ" THEN\
120:           ENTERED.WORD$=LEFT$(ENTERED.WORD$,LEN(ENTERED.WORD$)-2)+"ER":\
121:           GO TO 85
122:
123:        IF RIGHT$(ENTERED.WORD$,2)="ER" THEN\
124:           ENTERED.WORD$=LEFT$(ENTERED.WORD$,LEN(ENTERED.WORD$)-2)+"OIR":\
125:           GO TO 85
126:
127:        PRINT "WAS YOUR WORD SPELLED CORRECTLY ?"
128:        GO TO 75
129:
130:        END
  1:
```

Listing 2: *In this run of FRENGLSH the first prompt FR= ? was answered by typing "bonjour," and FRENGLSH found the corresponding English word "hello." In the third example, the word "voulez" is not the dictionary form of the verb. The* **-ez** *ending signifies it is second-person present tense. FRENGLSH did not therefore find "voulez," so it looked for the stem of the word with common infinitive endings,* **-er** *or* **-oir**. *"Vouloir," the correct infinitive form of the verb, was found and the corresponding English was printed.*

```
                         PROGRAM FRENGLSH

                A FRENCH-ENGLISH-FRENCH DICTIONARY


STARTING MODE IS FRENCH-ENGLISH. TO REVERSE MODE
ENTER A 1 INSTEAD OF A WORD

TO END THE PROGRAM ENTER A 9 INSTEAD OF A WORD


PLEASE WAIT 40 SECONDS WHILE WE LOAD


ENTER FRENCH WORD AFTER FR=  OR ENGLISH AFTER EN=




FR= ? BONJOUR
BONJOUR = HELLO


FR= ? ATTERIR
ATTERIR = TO LAND (AIRPLANE)


FR= ? VOULEZ
VOULEZ NOT FOUND.  VOULER NOT FOUND.  VOULOIR = TO WANT


FR= ?
```

ending in -ez. For example, *vouloir* means "to want" while *voulez* means "you want." *Parler* means "to talk" and *parlez* means "you talk." If the word you give to FRENGLSH ends in -ez and is not found in the DICTION file, FRENGLSH will search for the root of the word with an -er ending, and, if that fails, for an -oir ending (lines 116 thru 128 in listing 1). Only if those additional two searches are unsuccessful does FRENGLSH report failure.

As can be seen, at 130 lines, including comments and blank lines, FRENGLSH is not a very long program. Of course, the real problem is in creating the DICTION file with its thousands of words. This was done by using several other programs. One program permitted the entry of word pairs, assigning the correct separator, and writing the list to a file which was then corrected using the system editor. These lists were concatenated as they were created, and the completed list was split into twenty-six separate lists, each beginning with a different letter of the alphabet. These individual lists were then proofread, corrected, concatenated, and alphabetized to make a single long file. The final file was then read by a program which created the DICTION file by inserting slashes between the word pairs and assembling the pairs into records of 204 or less characters. Finally a small program was used to read the first word in each record in the DICTION file, together with its record number, to create FRINDEX, the index file.

FRENGLSH is quite fast. Most of the time it is considerably faster than thumbing the pages of a paper dictionary, especially for people like me who have never really learned which letters follow which in the alphabet. ■

Z80 User Stack Emulation

Allen Gelder, Box 11721 Main Post Office, San Francisco CA 94101

Passing arguments to subroutines via the Z80 hardware stack is complicated by the presence of the subroutine return address at the top of the stack. This artifact of the CALL instruction makes a cork-in-the-bottle effect that precludes just PUSHing the arguments onto the stack and later POPing them into the subroutine after the CALL. The problem is solved on the new Motorola 6809 by the addition of a *user stack* which does

not participate in the CALL housekeeping. Such a structure is easily emulated and can be integrated very naturally into the Z80 instruction set by the use of the restart instruction group.

Recall that the restart (RST) instructions are 1-byte calls to selected page 0 locations. For example, hexadecimal op code D7 is RST 10. When program flow encounters this instruction, the program counter (register PC) will be pushed onto the stack and control will be transferred to location 0010. Often this location contains a vector to the actual routine, which will typically be concluded by a return (RET). This is the arrangement here (see listing 2, page 210). It is easy to link this emulation; just initialize UPSTOR with a 2-byte user pointer to the desired top of the user stack, and then vector the restarts as indicated. (See listing 1, page 210.)

When program flow encounters a D7 op code (RST 10), the result will be a POPU DE, that is, the top of the user stack will be popped into DE, and the user pointer (UP) will be updated. Similarly, a DF op code (RST 18) will result in a PSHU DE onto the top of the user stack, etc (see table 1). This action is perfectly consistent with current hardware stack usage, right down to the near congruence of the POPU and PSHU instruction bytes.

The difference is that this stack is totally controlled by the user, at very little programming expense. In the configuration of table 1, the user stack access covers the primary register pairs BC, DE, HL and AF. An alternative assignment (see listing 3, page 210, and table 2) of restarts can include registers IX and IY. This is at the expense of register pairs DE and AF, but saves one byte over the corresponding PUSH or POP IX (or IY) instruction.

Interpretation of the restart group of instructions is varied. In the literature, the restart instructions are described as saving space, useful for interrupts, or as leftover 8080 instructions. In practice they are often usurped by the input/output (I/O) software, or perhaps page 0 is submerged in read-only memory. If this is the case in your Z80-based system, it is worth looking for a vector table in programmable memory or in some other way gaining access to the restart instructions. Because they are an embedded group of 1-byte, user-programmable instructions, they bestow a kind of microprogrammability on the Z80.

User Stack Instruction				Hardware Stack Instruction	
POPU	BC	C7	(RST00)	POP BC	C1
PSHU	BC	CF	(RST08)	PUSH BC	C5
POPU	DE	D7	(RST10)	POP DE	D1
PSHU	DE	DF	(RST18)	PUSH DE	D5
POPU	HL	E7	(RST20)	POP HL	E1
PSHU	HL	EF	(RST28)	PUSH HL	E5
POPU	AF	F7	(RST30)	POP AF	F1
PSHU	AF	FF	(RST38)	PUSH AF	F5

Table 1: *Restart (RST) instructions assigned to user stack in listing 1.*

User-Stack Instruction				Hardware-Stack Instruction	
POPU	IX	D7	(RST10)	POP IX	DDE1
PSHU	IX	DF	(RST18)	PUSH IX	DDE5
POPU	IY	F7	(RST30)	POP IY	FDE1
PSHU	IY	FF	(RST38)	PUSH IY	FDE5

Table 2: *Restart (RST) instruction assignments made by modified user-stack emulation in listing 2.*

In this user stack setup, the restart instructions are exploited as 1-byte PSHU and POPU instructions in service of an emulated processor architectural feature. They could as easily call an emulated addressing mode not available on the Z80. The point is that an appropriate use of the restart group is in calling instruction-like subroutines that represent the primitives serving the user's own fanciful structure. Thus you can design your own corner of the Z80. Let your curiosity PSHU into trying it.

Listing 1: *Vectoring RST10.*

```
0010 C310 50    RST10     JP      FROM10      ; Now D7 calls FROM 10
```

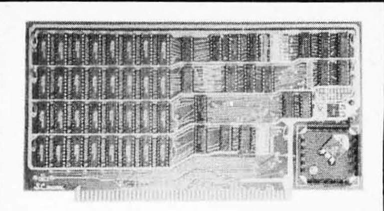
Listing 2: *Assembled program for Z80 user-stack emulation using restart (RST) instructions.*

```
5000                      ORG     5000H
5000 00         SPSTOR    NOP                 ; SP saved here.
5001 00                   NOP
5002 00         UPSTOR    NOP                 ; UP saved here.
5003 00                   NOP
5004 E5         FROM00    PUSH    HL          ; Vector C7 here.
5005 21C100               LD      HL,00C1H
5008 1828                 JR      USRSTK
500A E5         FROM08    PUSH    HL          ; Vector CF here.
500B 21C500               LD      HL,00C5H
500E 1822                 JR      USRSTK
5010 E5         FROM10    PUSH    HL          ; Vector D7 here.
5011 21D100               LD      HL,00D1H
5014 181C                 JR      USRSTK
5016 E5         FROM18    PUSH    HL          ; Vector DF here.
5017 21D500               LD      HL,00D5H
501A 1816                 JR      USRSTK
501C E5         FROM20    PUSH    HL          ; Vector E7 here.
501D 21E100               LD      HL,00E1H
5020 1810                 JR      USRSTK
5022 E5         FROM28    PUSH    HL          ; Vector EF here.
5023 21E500               LD      HL,00E5H
5026 180A                 JR      USRSTK
5028 E5         FROM30    PUSH    HL          ; Vector F7 here.
5029 21F100               LD      HL,00F1H
502C 1804                 JR      USRSTK
502E E5         FROM38    PUSH    HL          ; Vector FF here.
502F 21F500               LD      HL,00F5H
5032 223E50     USRSTK    LD      (OPSTOR),HL ; Place in OPSTOR.
5035 E1                   POP     HL
5036 ED730050             LD      (SPSTOR),SP ; Save the SP.
503A ED7B0250             LD      SP,(UPSTOR) ; Initialize User Stack.
503E 00         OPSTOR    NOP                 ; Event happens here.
503F 00                   NOP
5040 ED730250             LD      (UPSTOR),SP ; Save the UP.
5044 ED7B0050             LD      SP,(SPSTOR) ; Restore the SP.
5048 C9                   RET                 ; Back to program.
```

Listing 3: *Alternate assembled listing to include index registers IX and IY. These two sections of code are directly substituted for the code in listing 2.*

```
.
.
.
5010 E5         FROM10    PUSH    HL          ; Vector D7 here.
5011 21DDE1               LD      HL,E1DDH
5014 181C                 JR      USRSTK
5016 E5         FROM18    PUSH    HL          ; Vector DF here.
5017 21DDE5               LD      HL,E5DDH
501A 1816                 JR      USRSTK
.
.
.
5028 E5         FROM30    PUSH    HL          ; Vector F7 here.
5029 21FDE1               LD      HL,E1FDH
502C 1804                 JR      USRSTK
502E E5         FROM38    PUSH    HL          ; Vector FF here.
502F 21FDE5               LD      HL,E5FDH
5032 223E50     USRSTK    LD      (OPSTOR),HL ; Place in OPSTOR.
.
.
.
```

■



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Eighteen with a Die
A Learning Game Player

Russell R Yost Jr
1825 E Palo Verde Dr
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The simulation of human intellect by a machine of human invention has fascinated mankind for centuries. Unfortunately, the attainment of such a goal still seems to be distant. The advances in machines that might achieve such a goal seem to be continually offset by additions to our knowledge of the complexity of the human intellectual process. Simple game-playing machines, however, are feasible, and their popularity probably stems from the above mentioned human yearning, even though these games represent only a narrow slice of human intellect.

Game-playing programs are of great value to the personal computer owner, since results of great interest to spouse and neighbors can be produced with only a small investment in memory and software. Rarely do such programs involve more than logic plus simple integer arithmetic, and they are so short that hand assembly of machine-language programs is entirely feasible.

Many games are well adapted to interaction with the human player through the same I/O (input/output) channel used for programming. I am sure that the first program tried by most buyers of the Southwest Technical Products Corp 6800 computer system (after some memory check programs) is the Tic-Tac-Toe program whose listing is supplied with the computer kit.

Although such beginner games soon become boring, game-playing programs of real and continuing challenge are now becoming feasible for all amateur computer owners. Meanwhile, simple game players such as the one described here continue to intrigue computer enthusiasts.

Game Categories

Thus far I have been using the term "game player" loosely, and indeed the term is loosely used in many articles. Three distinct categories are easy to define: puzzles, gambling machines, and man versus machine game players.

It seems to me that a game like Shooting Stars (by Willard I Nico, May 1976 BYTE, page 42) is really a puzzle that the human tries to solve in as few moves as possible. Star Trek-type games might be considered examples of a gambling program. Through the use of random number generators, the human's moves produce random results following prescribed odds; luck is involved in the result.

Tic-Tac-Toe is an example of a man versus machine game. The machine plays the role of an adversary, playing by the same rules that apply to the human.

This last category comes the closest to the simulation of human intellect, which is why I feel it is of great interest to the computer owner. However, all three types of games are interesting to players, and many games combine elements of all three in their architecture.

Game Learning Program

A natural extension of the third category is the game learning and playing program. In this type, the machine is given the rules of the game, but initially does not possess any strategy for selecting its moves. Through playing a series of games with the human, it learns a strategy for increasing its chances of winning. This type comes even closer to the simulation of human intellect.

The design of such machines has been one of my hobbies for over thirty-five years. I recently purchased a computer because my ambitions outgrew what could be built using relays and stepping switches, or even

About the Author

Russell Yost studied physics at the California Institute of Technology before World War II diverted him into working on defense electronic systems. Since 1952 he has worked for Motorola; he is now the chief engineer for radar systems in the Government Electronics Division. When he saw the rising tide of microprocessor electronics, he bought a Southwest Technical Products 6800 computer system to gain experience in the new field. He uses the 6800 system to design logic circuits at home; at work he writes FORTRAN programs for simulation on a Sigma 5 computer. He is active in amateur radio and photography.

small-scale integration logic elements. Software generation for such machines is now my current hobby.

The learning process can be implemented in various ways. One way is the "reward or punishment" approach exemplified by the game Hexapawn, which was described by Martin Gardner and based on a learning machine developed by Donald Michie. (See "Mathematical Games," *Scientific American*, volume 206, number 3, March 1962, page 138.)

The computer's response to each game situation is selected at random from a set of legal moves whose individual selection probabilities are the result of a previous experience. After each game in which the computer wins, the moves that it used are enhanced in probability. After each game it loses, the moves that it used are reduced in probability.

Gardner presented a simple model of such a game in which each response was the label of a box containing a certain number of beads. Losing moves were penalized by the removal of beads; winning moves had beads added to their boxes. The probability of selecting a given move in future games was related to the number of beads contained by its box. Robert Weir described a simpler process in which the various response probabilities were either 0 or 1 ("Hexpawn: A Beginning Project in Artificial Intelligence," November 1975 BYTE, page 36).

Win Table

Another learning process is the construction of a table of winning moves for each position or situation of the game. Many games are characterized by the existence of such a table. Each player tries to move to prevent the other player from getting to a winning situation in the table. Such a table is sometimes referred to as a *game tree* because of the multiple branches that lead to a single final winning position represented by the trunk of the tree.

For learning, the machine can initially be given the table of all possible moves for each game situation, with winning moves unidentified. For each situation the machine plays from, it fills in the winning moves by determining which of its permitted moves prevent the player from reaching a winning situation. Furthermore, after making its move, the machine may

In a game-learning program, the machine is given the rules of the game, but initially possesses no strategy for selecting its moves.

again analyze the new situation, before allowing the player to take his or her turn.

For the early games in a sequence of games, when most of the winning moves are unidentified, this process produces many errors. However, when the end of the game can be reached from the situation being analyzed, this process correctly identifies winning moves.

In subsequent games of a series, the correct entries appearing close to the end of the game permit the correction of earlier errors. To do this, the computer designates as *losing* moves those resulting in a situation from which the player can, with a legal move, attain a winning situation.

The net result is that during a series of games, the win table, which originally identified none of the winning moves, is gradually improved until it contains no significant errors and a sufficient number of winning moves to enable the machine to play faultlessly. Thereafter, one of the two players has no chance to win unless the other errs. Naturally, the game must be arranged so that the losing player is the human player; otherwise the learning process would not be apparent.

The above process of computer learning is quite similar to the way a human would learn to play such a game. At the start of the early games, play would be more or less random. Near the end of each game the beginning player would consider the opponent's legal responses to each of the permitted moves, and would try to select one that prevented a win by the opponent. In subsequent games the player would remember the situations from which he or she was able to win,

and would attempt to attain those positions earlier in the game.

There is another interesting parallel to human behavior in a machine that learns by this scheme. The machine's rate of learning (ie: the rate at which it corrects errors in the win table) is dependent on the skill of the human opponent. Since the human cannot win when the win table is error-free, the only way the new player can win early in a series of games is to take advantage of the errors, by playing to reach those situations for which the win table is erroneous. If this is done, the machine has an opportunity to analyze the results of moves from, and correct the errors for, that situation. On the other hand, if the human plays poorly and does not take advantage of the machine's errors, the machine does not correct the errors for early game situations, but wins in the end game.

A final, and most provocative parallel to the learning process of living systems is the need for random trials to discover winning moves that have been erroneously erased or never discovered. In analyzing a given situation, the machine sometimes cannot find a winning move because of an error in a situation closer to the end of the game. I found that no fixed preprogrammed move strategy would guarantee that the machine would correct such an error.

It was absolutely essential for the machine to try moves at random each time it analyzed that situation until it "accidently" made the correct move, played to the erroneous situation, and then corrected the error residing there. This is a striking analogy to the random attempts of the smallest insect (or for that matter, a human baby) to manipulate its environment.

A Suitable Game

As implied above, it is essential to find a simple game to demonstrate learning by filling in the win table. At the same time, the game must be challenging enough to maintain the interest of its human player. Eighteen with a Die is such a game.

I discovered a variant of the game in a book by Geoffrey Mott-Smith a number of years ago (Geoffrey Mott-Smith, *Mathematical Puzzles for Beginners and Enthusiasts*, The Blakistone Co, Philadelphia PA, 1946). As described, the game was

played with a die (half of a pair of dice). One player makes a random roll for his first play. Thereafter each player, in turn, turns one of the four vertical faces of the die upward by rotating it 90 degrees in a direction of the player's choice. A running total of all the plays is kept, and the object is to make the total hit a given target value on the move. Mott-Smith used the goal number of thirty-one.

I have shortened the game to the goal number of eighteen, and have allowed the first player a free choice for the first move, rather than making it random. Mott-Smith described an algorithm by which, given the current total and the last player's move, a winning play could be derived. However, it was not infallible, particularly near the end of the game. Thus the idea of the win table evolved as the approach to a learning machine.

Since the opposite faces of a die sum to seven, the rules for Eighteen with a Die become the following: after the first play, each player may play a number from one to six inclusive, but it may not be the number just played by his opponent nor its complement with respect to seven. Thus, if the total is seventeen, one is a winning play if the opponent has not just played one or six. Sixteen is always a winning situation for the player whose turn it is. The player can win by playing two, or if that is not legal, by playing one, which prevents the opponent from hitting eighteen exactly on his turn.

The machine's rate of learning is dependent on the skill of the human opponent.

Electromechanical Game Player

In 1959 I designed and constructed a relay and stepping-switch machine that demonstrated this learning game. I called it GLIM, for Game Learning Intelligent Machine. Photo 1 shows GLIM and the author (quite a *bit* younger then). Each memory bit was implemented as a pair of neon lamps sharing a common dropping resistor.

One of the lamps of each pair was used internally as part of the memory readout system. The other was included in a random display on the front panel which was shaped somewhat like a human brain. Though randomly arranged (to prevent utilization by the human player), the lamps that would be lit when the win table was error-free were located in the upper part of the brain display. Thus the degree to which the machine had become "highly" educated could be estimated.

The memory was read out by a motor-driven scanner containing six photocells, one for each of the six plays that the machine might make. A servo-mechanism positioned the scanner over a 6 by 18 array of neon lamps so that the photocells could

Photo 1: *The author with Game Learning Intelligent Machine (GLIM) in 1959. GLIM was a machine built with hard-wired logic in the form of relays and stepping switches that played the game Eighteen with a Die. It was a forerunner of the general-purpose computer of today that uses software to play the same game. GLIM contained eighteen 6-bit words of memory consisting of pairs of neon lamps, one pair for each bit. Each lamp pair had a common, current-controlling dropping resistor.*



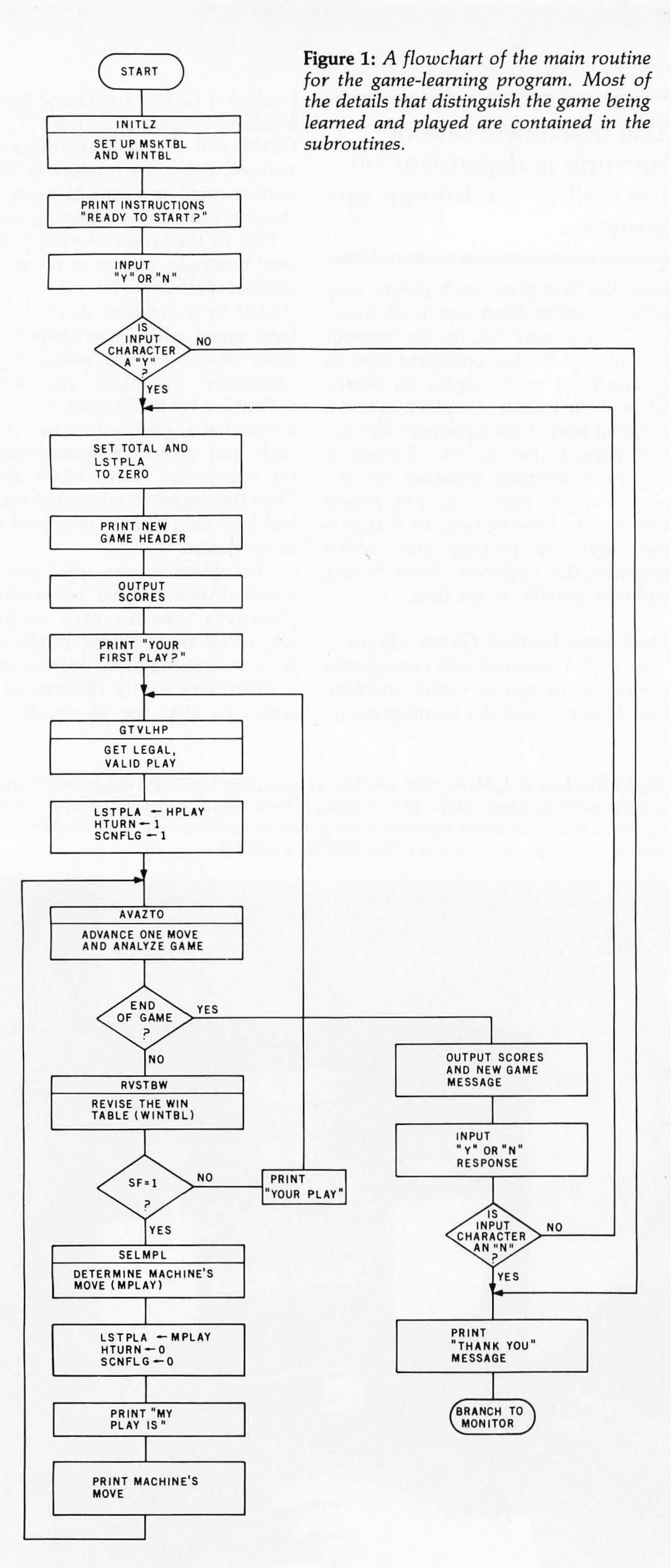


Figure 1: *A flowchart of the main routine for the game-learning program. Most of the details that distinguish the game being learned and played are contained in the subroutines.*

scan ahead in the memory, looking for lighted memory cells through a "legal play" mask mounted on the scanner. Plexiglas light collectors formed an optical OR function, while the mask formed an AND with each neon cell.

For example, the photocell that looked at the row of memory corresponding to the current total plus a move of one was masked so that it could see only the neon lamps in columns 2, 3, 4, and 5 of the memory array. These are the human's legal responses to a play of one. The next photocell could see only columns 1, 3, 4 and 6. Similar logic is embodied in the program described in this article.

As described above, the machine would play faultlessly after its win table was error-free. With the goal number of eighteen, the first player (the human) has no winning play and is doomed to lose every game after the machine has learned the game. To make the game more interesting, the logic was designed to cause the machine to "goof" occasionally. It skipped the procedure of picking out a winning move and merely selected a random legal play. In the program given here this is available as a software option. If selected, the goofs occur at random (controlled by a pseudo-random number generator) about once every eight machine plays.

Software Game Player

Figure 1 shows the flowchart of the main program for Eighteen with a Die. As can be seen, it is quite general. Most of the details that characterize it for this particular learning game are contained in the subroutines which are described below. The storing of human play (HPLAY) and machine play (MPLAY) in lastplay (LSTPLA) is an exception. Another exception is the setting of scan flag (SCNFLG) to allow the win table (WINTBL) to be updated both before and after the machine's play is added to the total.

The initialization subroutine (INITLZ) is flowcharted in figure 2. Mask table (MSKTBL) is initialized with a pattern of ones that correspond to legal responses to plays represented by the row indices. The least significant bit (LSB) represents a response of one.

Next, win table (WINTBL) is ini-

Input Character	Hexadecimal ASCII	CT1024 Terminal Response	SwTPC Peripheral Response
Control-P	10	Cursor home up	Same
Control-U	15	Erase to end of line	Same
Control-V	16	Erase to end of page	Same

Table 1: *Use of cursor and cassette tape control characters assumed in this program, compared with uses recommended by Southwest Technical Products Corp.*

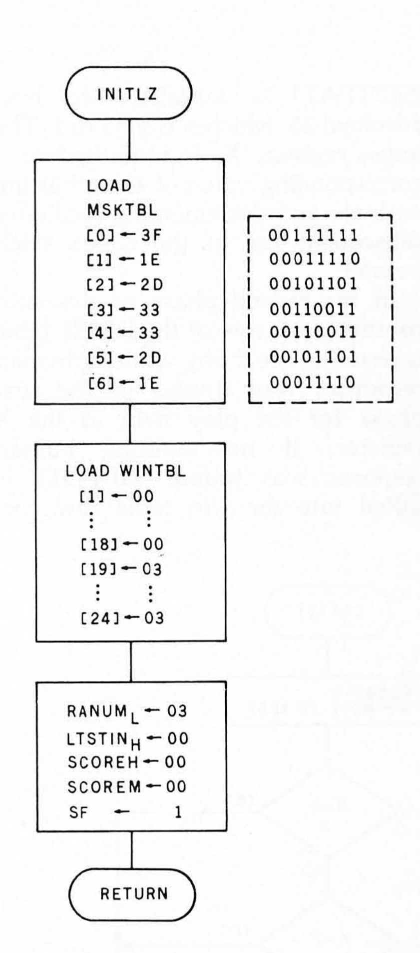


Figure 2: *Flowchart of the initialization subroutine (INITLZ). The bit pattern set into mask table (MSKTBL) signifies legal responses to plays denoted by the row numbers. Win table (WINTBL) is loaded with blanks until the six rows after the game end. These rows are loaded to cause correct winning plays to be found during game playing.*

tialized. Rows 1 through 18 are cleared, signifying no winning moves. However, rows 19 through 24 (those reachable by attempted plays from 18) are loaded with ones in both the 1 and 2 columns. One or both will represent a legal, winning human response, and will cause correct win or lose move information to be recorded in one or more of the columns of win table rows 13 through 18, when individual games have progressed that far. RANUM must be initialized to any nonzero value for the pseudorandom number generator.

LTSTIN is a 2-byte variable that is the operand for the legal test (LGLTST) subroutine. The low-order byte could be loaded and utilized before a double-precision load and test is made, so the high-order byte must be initialized to zero. SCOREH and SCOREM are used to accumulate the human's and machine's scores, and must start from zero for each series of games.

After initialization, the main program prints the game instructions, ending with the question, "READY TO PLAY?" All such messages and formats are stored as strings of ASCII characters, terminated by hexadecimal 04 (Control-D, or EOT).

After loading the microprocessor's X register with the starting address of the string, the string is output by a subroutine starting at hexadecimal E07E in the MIKBUG monitor. It tests for hexadecimal 04, outputs the character to the terminal, increments the X register, and recycles. Detection of a hexadecimal 04 causes a return to the user program. If you do not have MIKBUG or a similar monitor, you can easily write this subroutine.

Next, a human response to the question at the end of the instructions is sought, a Y, or N, signifying yes or no. Again, a MIKBUG subroutine INEEE (location E1AC) is used for this process. The ASCII character representing the human's response ends up in the A accumulator. After the human's response to this question, one of two messages is printed.

Both begin by erasing the instructions.

For a Y response, the message then comprises the new game header, while the "thanks for playing" message occurs for any other response. Instruction erasure is performed by ASCII control characters at the start of each of these two messages that activate cursor-home and erase-to-end-of-page (EOF). The ASCII codes I have used for such terminal controls are shown in table 1. The codes are compatible with those recommended by SwTPC.

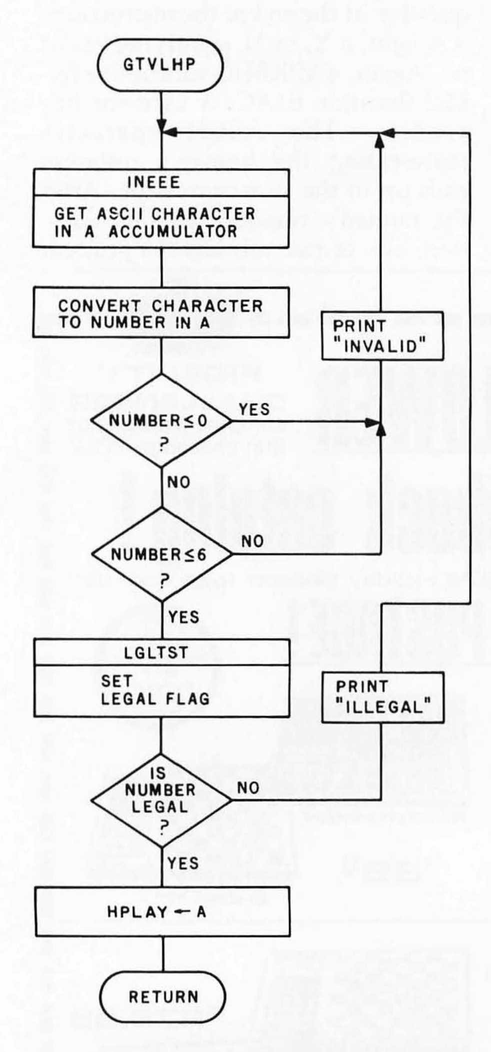


Figure 3: *Flowchart of subroutine to get a valid, legal human's play (GTVLHP). A MIKBUG subroutine (INEEE) is used to input a move. After verifying that the play is in the valid range 1 through 6, LGLTST is called to see if the move is legal.*

The "goof" feature causes the computer to make an occasional mistake.

Figure 3 shows the flowchart for the subroutine get valid legal human play (GTVLHP). This begins by looking for an ASCII character from the keyboard to be loaded into accumulator A, which is accomplished by using the MIKBUG INEEE subroutine. Subtracting hexadecimal 30 converts the ASCII code to a binary number, which is tested to determine if it is in the range 0 through 6. If the number is not in this range, an "invalid" message is printed. It is then subjected to the legal test (LGLTST) subroutine, figure 4, where it is compared with last play (LSTPLA) according to the rules governing legal plays. Legal plays are then loaded into HPLAY. Illegal plays are denoted by setting the zero flag bit in the M6800's condition register to one.

Figure 5 shows the flowchart for the subroutine advance and analyze total (AVAZTO). Two totals are actually calculated. One is TOTBCD, a binary-coded-decimal version of the total that is output to the terminal. Each time it is augmented by adding LSTPLA to it, the 6800 decimal adjust instruction (DAA) is employed to restore the number to binary-coded-decimal form. TOTAL is the total in hexadecimal notation and is used in the program for detecting the end of the game, advancing the win table index, etc. If the total equals or exceeds hexadecimal 12 (decimal 18), the flag, ENDGAM, is set, and the win or lose logic decides who won and increments the scores acccordingly. The scores are used only for display, and are stored in binary-coded-decimal form.

The next subroutine used is revise win table (RVSTBW), shown in figure 6. This process is accomplished in two steps. First, the rows of the win table corresponding to trial machine plays of 1 through 6 are ANDed with corresponding rows of mask table, which contain the legal responses to those plays. The results are stored in a 6-byte table of winning human response flags (WHRF).

Next, machine trial play pattern (MPTPAT) is initialized to hexadecimal 20, which sets bit 5 to 1. The index register, X, is initialized to a corresponding value of six. Starting with six and decrementing facilitates subsequent use of the 6800's stack pointer.

In the second phase of this subroutine, each row of the WHRF table is tested to see if any winning human responses were found in the first phase for the play held in the X register. If no winning human response was found, MPTPAT is ORed into the win table row cor-

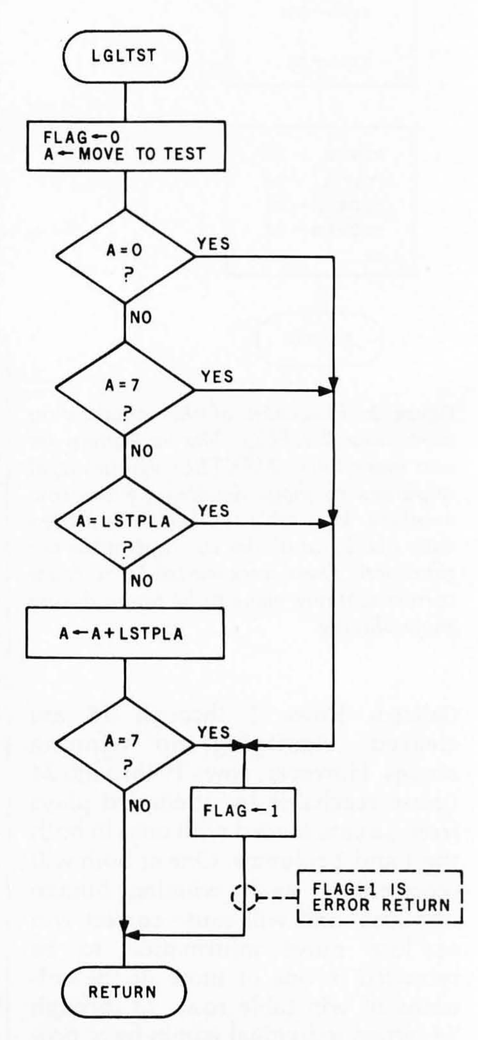
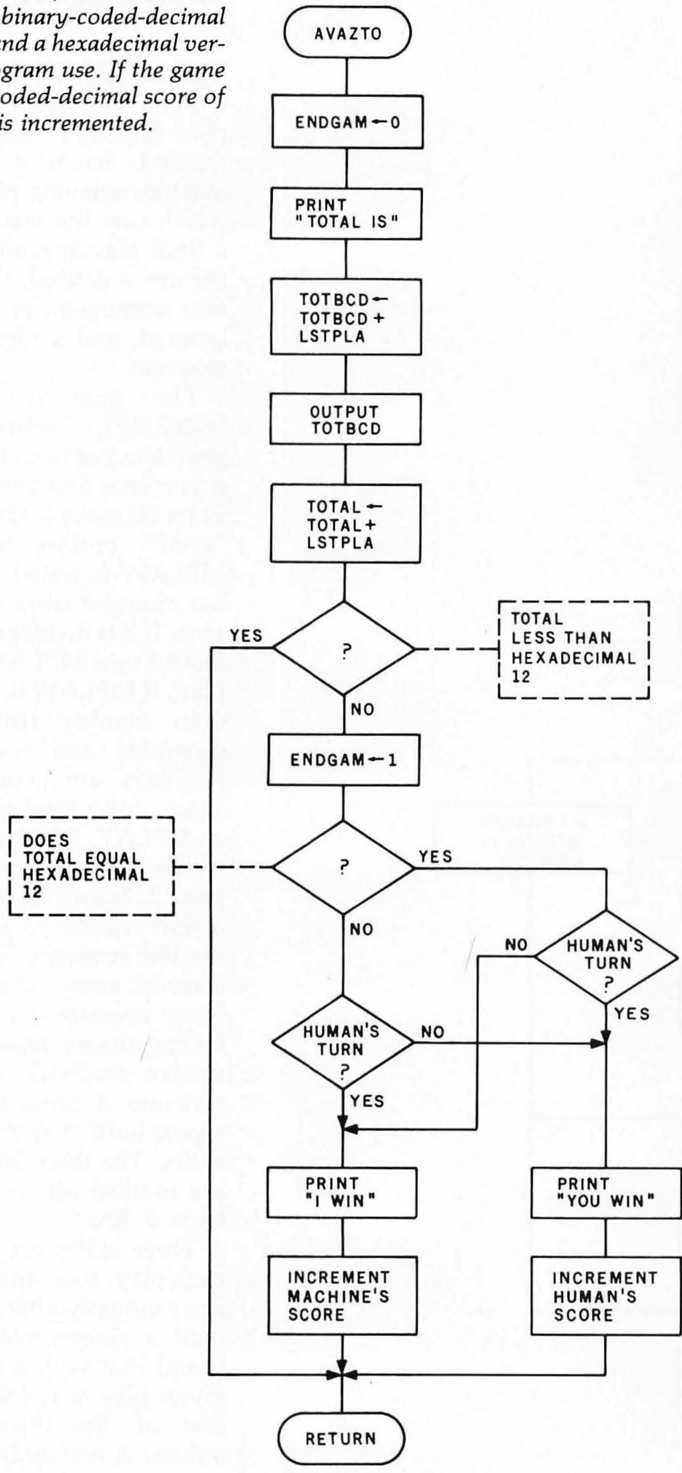


Figure 4: *Flowchart of the legality testing subroutine (LGLTST). The legal-move flag is first cleared to indicate an acceptable move. The computer-generated random plays of 0 and 7 are rejected. A trial play is then compared with the last play (LSTPLA) and with a value of 7+LSTPLA to implement the rules. If the flag returns from this routine with a value of 1, the move is not legal.*

Figure 5: *Flowchart of the subroutine for game analysis (AVAZTO). LSTPLA is added to two totals, a binary-coded-decimal version for display and a hexadecimal version for internal program use. If the game is over, the binary-coded-decimal score of the winning player is incremented.*



responding to the current total, to add an apparent winning move to the row. If any winning human response was found, the Xth column of the win table row corresponding to the current total is zeroed, by being ANDed with the one's complement of MPTPAT, thus deleting any erroneous winning play indication.

In the first case, X represents an apparent winning play for the machine, so it is tested to determine if it is a legal play. If so, it is stored in machine play, winning (MPLAW). X is then decremented and MPTPAT is shifted right by one place, to correspond to a play of five, and the second phase is repeated. At the conclusion, MPLAW holds the smallest winning play discovered, and the win table

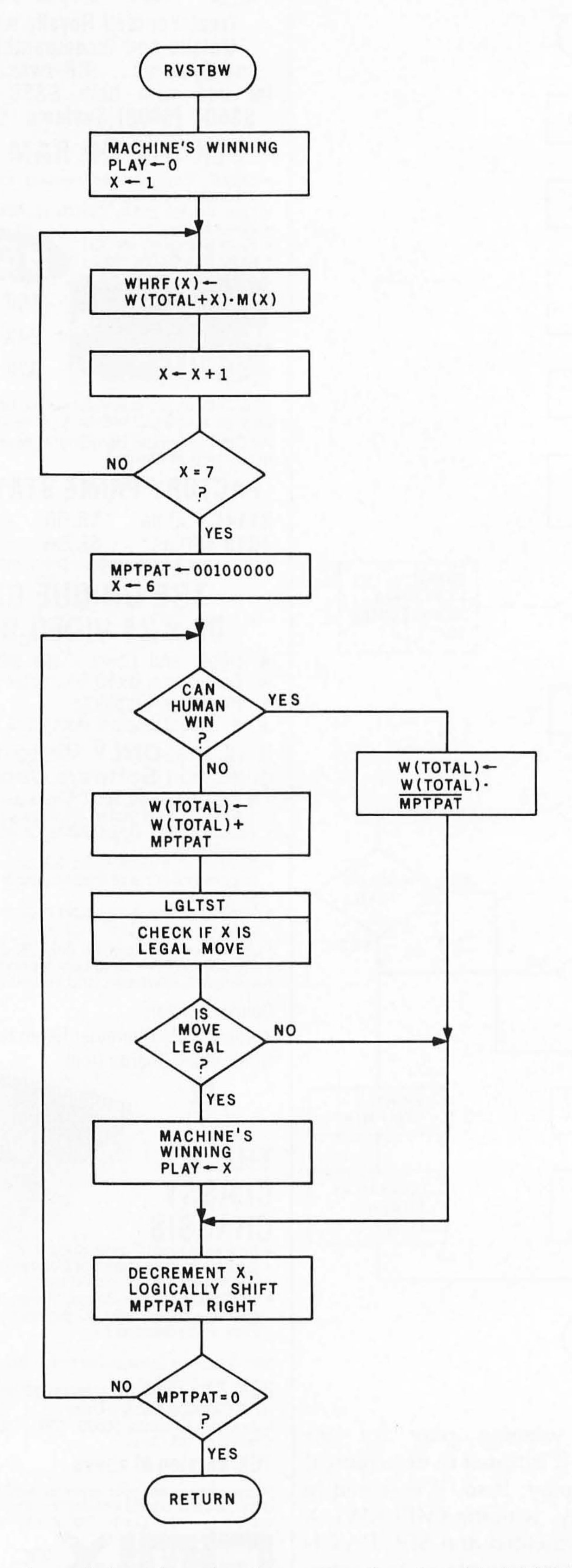


Figure 6: *Flowchart of the subroutine that revises the win table (RVSTBW). The win table row corresponding to the total before and after the computer's play is revised by trying all possible computer plays, and by selecting those plays that block the human from a legal winning response. The smallest apparent winning computer play is saved in MPLAW. The following logical notation is used: "·" is logical AND, "+" is logical OR.*

row for the current total has been updated, based on examining the next six rows of the win table.

Making the Machine Fallible

The subroutine select machine play (SELMPL) shown in figure 7 is needed because sometimes no machine winning plays are found, in which case the machine must choose a legal play at random. If the "goof" feature is desired, the program's current winning move (MPLAW) will be ignored, and a random play will be selected.

The generate random play (GNRNPL) subroutine actually generates numbers from 0 thru 7. The occurrence of a zero causes the computer to make a random move if the "goof" option is active. Next, MPLAW is tested to determine if it has changed from its initial value of zero. If it is no longer zero, its value is loaded into MPLAY as the machine's play. If MPLAW is zero, another random number from 0 thru 7 is generated and tested for legality. Numbers are generated again and again until a legal one is found for use as MPLAY, the machine's move.

The GNRNPL subroutine (figure 8, page 229) uses logic feedback around a shift register to generate a pseudorandom sequence. Two bytes plus the carry bit comprise a 17-stage register. Since seventeen is a prime number, coding theory assures us that every unique feedback arrangement will generate a sequence that will not repeat until after $2^{17} - 1$ (or 131,071) shifts. The three least significant bits are masked off to generate numbers from 0 thru 7.

Three shifts are used to generate each play, to assure that all three bits are randomly changed. I could have used a shorter shift register, but I found that with a shorter register, a given play was followed by only a few of the theoretically possible values. A few additional instructions are required to implement the 17-stage register, in which any given play will be followed with nearly equal probability by *all* of the values 0 thru 7.

The feedback comprises the Exclusive-OR of the zero and third order bits. This is accomplished by ANDing the low-order byte with hexadecimal 09. The carry bit is set to one if the result is one or eight and to zero if the result is zero or nine. The carry bit is

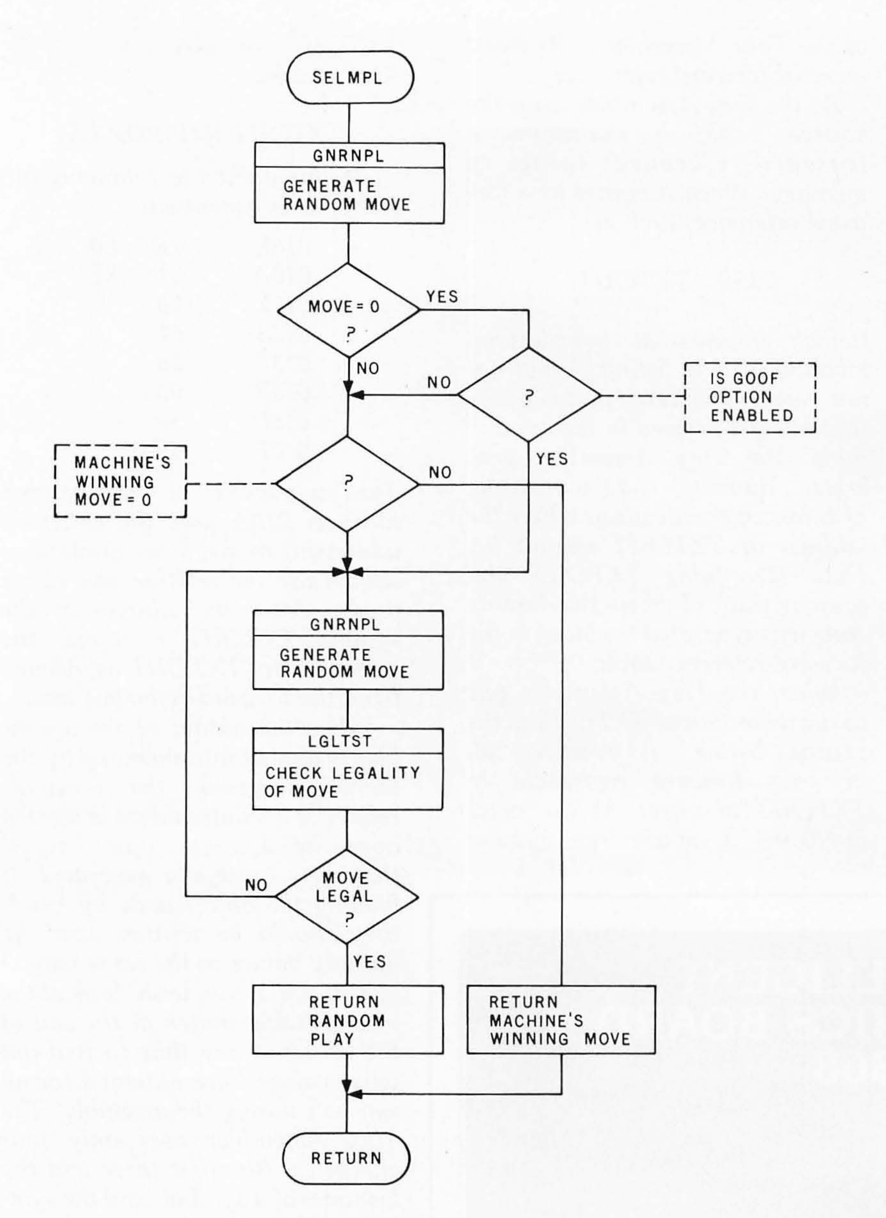


Figure 7: *Flowchart of the subroutine that determines the machine's play (SELMPL). If the goof option is selected, the odds are one in eight that the computer will make a random legal play, instead of playing the apparent winning play discovered while revising the win table. If no winning play is found, a random play is made.*

then shifted into the most significant bit of the high-order byte. The least significant bit is shifted into the carry and then into the most significant bit of the low-order byte. The latter's least significant bit is discarded.

During initialization, at least one of the shift register bits must be set to one, otherwise only zeros would circulate endlessly. The full 17-bit word cannot take the value zero, but the three least significant bits can take this value.

Other Random Methods

The above scheme has the disadvantage that the sequence is fixed by the initialization constant, so that each new series of games set up by loading the program start out with the same sequence of random plays. If the human should play the identical sequence of moves for a whole series of games, the machine's responses to those moves would not vary.

I have employed a way around this in other machines using the player's response time, measured in sufficiently small units, to generate random numbers. For example, three asynchronous free-running flip-flops at frequencies of 100, 141, and 173 Hz can be allowed to run during the time the computer is waiting for the human to respond. When stopped by the response, they will represent a random binary number from 0 thru 7 that depends on the human's response time measured in hundredths of seconds, modulo 7. Using frequencies related by ratios close to $\sqrt{2}$ and $\sqrt{3}$ assures that the flip-flops will generate a relatively long sequence (of order 100) before repeating.

This approach was not feasible, however, when using a MIKBUG subroutine to get the human's response.

Listing 1 is the program listing in assembler format for the SwTPC 6800. MIKBUG subroutines were freely used for input and output. All constants and variables are stored on page one of memory, starting at hexadecimal address 0020. The initialization subroutine is also stored here. The main program begins at hexadecimal 0100. Messages start at hexadecimal 02D0 and extend to hexadecimal 057F. About 1380 (decimal) bytes are needed. Addresses from 0000 to 001F were not used, in compliance with SwTPC's suggestion that these be reserved for a disk operating system.

You may wish to revise message formats. Revisions of starting addresses will require revisions of the load index register (LDX #) instructions in the main programs and subroutines wherever the messages are printed.

How to Play Against the Machine

The human player has several options for competing with the machine. With the goof feature disabled, try to see how many games you can win, starting with the win table empty, before the machine is winning every game. Your strategy should be to induce the machine to load as many errors as possible into the win table, then play to inhibit the machine from correcting those errors.

When you have memorized all of the winning plays for each total, you will do better. This knowledge can be acquired through experience, or by examining the win table after the machine has thoroughly learned the game. Unless the goof feature is used, some winning moves may not be found by the machine, but it will find enough that one or more will be legal

Text continued on page 229

How to Use the Program Listing

The program in listing 1 was assembled using Jack Emmerichs's Tiny Assembler for the 6800 processor. Since this assembler operates using only one pass through the source code, it must handle forward references in a special way.

A forward reference *occurs during assembly when some instruction in the program references a symbol that appears* after *it in the source code. (A symbol is a label for an instruction or for data.) Since the assembler has not yet come to the referenced symbol and does not know what its address is, the assembler cannot initially generate the proper object code.*

If you have your own assembler, you will face no difficulty in using Eighteen with a Die (since you will probably wish to reassemble it on your own system). If you do not have an assembler in your 6800 system and want to enter the object code directly from listing 1, you must *be aware of the behavior of the Tiny Assembler in its treatment of forward references.*

As the Tiny Assembler scans the source code, it maintains a forward-reference table in memory. When it comes to a forward reference, such as:

JSR TXTOUT

(which appears at hexadecimal location 0109 in listing 1) that has not been encountered and is therefore not yet defined in the symbol table, the Tiny Assembler generates "dummy" code (consisting of zeros) in the locations where the address of TXTOUT should be. Data identifying TXTOUT and keeping track of where the dummy code was generated is placed in the forward-reference table.

When the Tiny Assembler gets to the definition of TXTOUT in the source listing, it resolves all previous forward references to TXTOUT at once. At the place in listing 1 where the symbol TXTOUT appears, we see the source code:

TXTOUT JMP PDATA1

At this point the following object code is generated:

018E	7E	E0	7E
010A	01	8E	
0117	76		
0126	67		
0137	56		
018B	02		
015D	30		
017F	0E		

The resolution of hexadecimal location 010A uses the extended addressing mode; other resolutions shown use the relative addressing mode. After the address of the symbol TXTOUT is found, the reference to TXTOUT is deleted from the forward-reference table.

When the output of the assembler is loaded into memory by the loader program, the forward-reference resolution data is written over the dummy values (zeros) that were originally generated. If loading the object code by hand, they should be written over the dummy values in the same way.

You can, if you wish, look at the symbol table shown at the end of the listing at any time to find out what values were obtained for all symbols during the assembly. The Tiny Assembler uses only four characters (the first three and the last one) of a symbol, and the symbol table uses these condensed symbols, not the full spellings found in the program.

Complete documentation about the Tiny Assembler appeared in the following BYTE articles by Jack Emmerichs: "Designing the Tiny Assembler: Defining the Problem," April 1977, page 60; "Implementing the Tiny Assembler," May 1977, page 84; "Expanding the Tiny Assembler," September 1977, page 44.

Reprints of these magazine articles plus PAPERBYTE® bar codes for optical scanning are available in book form under the title Tiny Assembler 6800, Version 3.1, *by Jack Emmerichs. You may obtain this book for $9.60 (including postage) from BYTE Books, 70 Main St, Peterborough NH 03458.*

Listing 1: *Complete assembler listing Eighteen with a Die as coded for the 6800 microprocessor in a system equipped with a MIKBUG (or MIKBUG-compatible) monitor.*

```
ØØØØ              >*******************************************
ØØØØ              >*                                         *
ØØØØ              >*           18 WITH A DIE                 *
ØØØØ              >*           VSN 2.Ø                       *
ØØØØ              >*                                         *
ØØØØ              >*        R. YOST          79-Ø7-18        *
ØØØØ              >*                                         *
ØØØØ              >*******************************************
ØØØØ              >
ØØØØ              >
ØØØØ              >*          EQUATES
ØØØØ              >
E1AC              >INEEE  EQU  $E1AC   MIKBUG SR: GET ASCII CHAR. IN 'A' REG
EØE3              >CONTRL EQU  $EØE3   MIKBUG MON. RET. POINT
EØCA              >OUT2HS EQU  $EØCA   MKBG SR : PRINT 2 HEX CHR'S + SPACE.
EØ6B              >OUTHR  EQU  $EØ6B   MKBG SR: PRINT RIGHT NYBBLE OF 'A' REG.
EØ7E              >PDATA1 EQU  $EØ7E   MKBG SR: STRING PRINTER, TERM'D BY $Ø4
ØØØØ              >
ØØØØ              >*      VARIABLES AND TABLES
ØØØØ              >
ØØ2Ø              >       ORG  $2Ø
ØØ2Ø              >MSKTBL RMB  7       LEGAL RESPONSES MASKS
ØØ27              >WINTBL RMB  18      TABLE OF WINNING PLAY BIT PATTERNS
ØØ39              >       RMB  7       SPACE FOR END GAME MARKERS
ØØ4Ø              >MPTPAT RMB  1       M. TRIAL PLAY PATTERN
ØØ41              >SCOREH RMB  1       H. AND M. BCD SCORES
ØØ42              >SCOREM RMB  1
ØØ43              >TOTAL  RMB  1       BINARY TOTAL OF ALL PLAYS
ØØ44              >TOTBCD RMB  1       DITTO, BCD
ØØ45              >HPLAY  RMB  1       VALID, LEGAL, H. PLAY
ØØ46              >LSTPLA RMB  1       OPPONENT'S PREV. PLAY
ØØ47              >HTURN  RMB  1       H. TURN FLAG
ØØ48              >SCNFLG RMB  1       SCAN WIN TABLE FLAG. 1 MEANS
ØØ49              >*                           BEFORE M'S PLAY;
ØØ49              >*                         O MEANS AFTER M'S PLAY.
ØØ49              >ENDGAM RMB  1        END GAME FLAG. SET IF TOTAL > 17.
ØØ4A              >LTSTIN RMB  2       DUMMY INPUT VARIABLE FOR LEGAL TEST
ØØ4C              >*                    2 BYTES ACCOMODATE X REG.
ØØ4C              >WHRF   RMB  6       TABLE STORES WINNING HUMAN RESPONSES
ØØ52              >*                    TO TRIAL M PLAYS.
ØØ52              >MPLAY  RMB  1       TRIAL M PLAY.
ØØ53              >MPLAW  RMB  1       WINNING M PLAY DETECTED IN REVISING
ØØ54              >*                    WIN TABLE.
ØØ54              >SSTO   RMB  2       TEMP. STK. PNTR STORAGE.
ØØ56              >WTBLRP RMB  2       WINTABLE ROW POINTER
ØØ58              >RANUM  RMB  2       RANDOM NUMBER SHIFT REGISTERS.
ØØ5A              >
ØØ5A              >*   SUBROUTINE INITIALIZE  - INITLZ
ØØ5A              >
ØØ5D              >       ORG  $5D
ØØ5D CE ØØ 2Ø     >INITLZ LDX #MSKTBL INITIALIZE MASK TABLE WITH
ØØ6Ø 86 3F        >       LDAA #$3F     LEGAL RESPONSE PATTERNS
ØØ62 A7 ØØ        >       STAA Ø,X      IN 6 LEAST SIG. BITS.
ØØ64 86 1E        >       LDAA #$1E
ØØ66 A7 Ø1        >       STAA 1,X
ØØ68 A7 Ø6        >       STAA 6,X
ØØ6A 86 2D        >       LDAA #$2D
ØØ6C A7 Ø2        >       STAA 2,X
ØØ6E A7 Ø5        >       STAA 5,X
ØØ7Ø 86 33        >       LDAA #$33
ØØ72 A7 Ø3        >       STAA 3,X
ØØ74 A7 Ø4        >       STAA 4,X
ØØ76 4F           >       CLRA           CLEAR WIN TABLE BEFORE
ØØ77 CE ØØ Ø1     >       LDX  #1          FIRST GAME.
ØØ7A A7 26        >I1     STAA WINTBL-1,X
ØØ7C Ø8           >       INX
ØØ7D 8C ØØ 13     >       CPX  #$13
ØØ8Ø 26 F8        >       BNE  I1
ØØ82 86 Ø3        >       LDAA #3          STORE  DUMMY H WIN PLAY
ØØ84 A7 26        >I2     STAA WINTBL-1,X  BITS BEYOND END OF WINTABLE
ØØ86 Ø8           >       INX              SO MACHINE CAN SEE END OF
ØØ87 8C ØØ 19     >       CPX  #$19        GAME COMING.
ØØ8A 26 F8        >       BNE  I2
ØØ8C 97 59        >       STAA RANUM+1 INITIALIZE RANDOM NUMBER GENERATOR
ØØ8E 4F           >       CLRA             SEED.
ØØ8F 97 4A        >       STAA LTSTIN  CLEAR HIGH BYTE OF L. TEST; ALSO
ØØ91 97 41        >       STAA SCOREH  DUMMY VAR. AND SCORES.
ØØ93 97 42        >       STAA SCOREM
ØØ95 39           >       RTS
ØØ96              >
ØØ96              >*   MAIN PROGRAM
ØØ96              >
Ø1ØØ              >       ORG  $1ØØ
Ø1ØØ 8E AØ 47     >       LDS  #$AØ47 PRESERVE STRT ADDR @ $AØ48,9.
Ø1Ø3 BD ØØ 5D     >       JSR  INITLZ
Ø1Ø6 CE ØØ ØØ     >       LDX  #MES1   PRINT INSTRUCTIONS AND
Ø1Ø9 BD ØØ ØØ     >       JSR  TXTOUT  ASK "READY TO PLAY".
Ø1ØC BD E1 AC     >       JSR  INEEE   GET RESPONSE;
Ø1ØF 81 59        >       CMPA #'Y     IF NOT 'Y' THEN
Ø111 27 ØØ        >       BEQ  M2
Ø113              >
Ø113 CE ØØ ØØ     >M1     LDX  #MES5   PRINT "THANKS, GOODBY",
Ø116 8D ØØ        >       BSR  TXTOUT
Ø118 7E EØ E3     >       JMP  CONTRL  AND EXIT TO MIKBUG.
Ø11B              >
Ø11B 4F           >M2     CLRA         ELSE, INITIALIZE VARS. FOR
Ø112 Ø8
Ø11C 97 43        >       STAA TOTAL     NEW GAME.
Ø11E 97 44        >       STAA TOTBCD
Ø12Ø 97 46        >       STAA LSTPLA
Ø122 CE ØØ ØØ     >       LDX  #MES2   PRINT NEW GAME HEADER.
Ø125 8D ØØ        >       BSR  TXTOUT
Ø127 CE ØØ 41     >       LDX  #SCOREH PRINT SCORES.
Ø12A BD EØ CA     >       JSR  OUT2HS
Ø12D CE ØØ 42     >       LDX  #SCOREM
Ø13Ø BD EØ CA     >       JSR  OUT2HS
Ø133 CE ØØ ØØ     >       LDX  #MES3   PRINT "YOUR 1ST PLAY?".
Ø136 8D ØØ        >       BSR  TXTOUT
Ø138 BD ØØ ØØ     >M3     JSR  GTVLHP  GET VALID LEGAL H. PLAY.
Ø13B 96 45        >       LDAA HPLAY   PUT IN HPLAY AND LAST PLAY.
Ø13D 97 46        >       STAA LSTPLA
Ø13F 86 Ø1        >       LDAA #1
Ø141 97 47        >       STAA HTURN   SET H. TURN FLAG,
Ø143 97 48        >       STAA SCNFLG  AND SCAN FLAG, TO DENOTE WIN TABLE
Ø145 BD ØØ ØØ     >M4     JSR  AVAZTO  REVISION BEFORE M. PLAY.  ADD PLAY
Ø148              >*                   TO TOTALS. SET END GAME  FLG. IF
Ø148              >*                   TOTAL > 17, AND CALC. SCORES.
Ø148 7D ØØ 49     >       TST  ENDGAM
Ø14B 27 ØØ        >       BEQ  M5
Ø14D CE ØØ 41     >       LDX  #SCOREH  IF GAME OVER, PRINT SCORES.
Ø15Ø BD EØ CA     >       JSR  OUT2HS
Ø153 CE ØØ 42     >       LDX  #SCOREM
Ø156 BD EØ CA     >       JSR  OUT2HS
Ø159 CE ØØ ØØ     >       LDX  #MES4   PRINT "NEW GAME?".
Ø15C 8D ØØ        >       BSR  TXTOUT
Ø15E BD E1 AC     >       JSR  INEEE
Ø161 81 4E        >       CMPA #'N     IF RESPONSE = 'N', PRINT THANKS,ETC, &
Ø163              >*                   ETC, AND EXIT.
```

Listing 1 continued on page 224

Listing 1 continued:

```
Ø163 27 AE    >        BEQ  M1
Ø165 2Ø B4    >        BRA  M2     ELSE, SET UP NEW GAME.
Ø167          >
Ø167 BD ØØ ØØ >M5      JSR  RVSTBW IF GAME NOT OVER, LOOK AHEAD FOR
Ø14C 1A
Ø16A          >*                    H RESPONSES TO M TRIAL PLAYS
Ø16A          >*                    AND REVISE WIN TABLE.
Ø16A 7D ØØ 48 >        TST  SCNFLG  IF SCAN FLAG CLEAR, THEN
Ø16D 27 ØØ    >        BEQ  M6      GET NEXT H. PLAY.
Ø16F BD ØØ ØØ >        JSR  SELMPL ELSE, SELECT M. PLAY.
Ø172 96 52    >        LDAA MPLAY
Ø174 97 46    >        STAA LSTPLA
Ø176 4F       >        CLRA        CLEAR SCAN FLAG TO REVISE WIN TABLE BY
Ø177          >*                    LOOKING AHEAD AFTER M'S PLAY.
Ø177 97 48    >        STAA SCNFLG
Ø179 97 47    >        STAA HTURN  CLEAR H. TURN FLAG.
Ø17B CE ØØ ØØ >        LDX  #MES6  ANNOUNCE M'S PLAY,
Ø17E 8D ØØ    >        BSR  TXTOUT
Ø18Ø 96 52    >        LDAA MPLAY
Ø182 BD EØ 6B >        JSR  OUTHR
Ø185 2Ø BE    >        BRA  M4      AND PROCESS IT.
Ø187          >
Ø187          >
Ø187 CE ØØ ØØ >M6      LDX  #MES7  IF SCAN FLAG WAS RESET, REQUEST
Ø1SE 18
Ø18A 8D ØØ    >        BSR  TXTOUT  NEXT H. PLAY,
Ø18C 2Ø AA    >        BRA  M3      AND GET IT.
Ø18E          >
Ø18E 7E EØ 7E >TXTOUT JMP  PDATA1 BSR TARGET FOR MIKBUG STRING PRINT
Ø1ØA Ø1 8E
Ø117 76
Ø126 67
Ø137 56
Ø18B Ø2
Ø15D 3Ø
Ø17F ØE
Ø191          >
Ø191          >*  SUBROUTINE GTVLHP - GET VALID LEGAL H. PLAY.
Ø191          >
Ø1AØ          >        ORG  $1AØ
Ø1AØ BD E1 AC >GTVLHP JSR  INEEE   GET H. KEYBOARD INPUT;
Ø139 Ø1 AØ
Ø1A3 8Ø 3Ø    >        SUBA #$3Ø   CONVERT TO HEX.
Ø1A5 2F ØØ    >        BLE  G1     IF LESS THAN 1,
Ø1A7 81 Ø6    >        CMPA #6
Ø1A9 2F ØØ    >        BLE  G2      OR GREATER THAN 6.
Ø1AB          >
Ø1AB CE ØØ ØØ >G1      LDX  #MES8  PRINT "INVALID"
Ø1A6 Ø4
Ø1AE 8D DE    >        BSR  TXTOUT
Ø1BØ 2Ø EE    >        BRA  GTVLHP  AND TRY AGAIN.
Ø1B2          >
Ø1B2 97 4B    >G2      STAA LTSTIN+1 CHECK H. PLAY FOR LEGALITY.
Ø1AA Ø7
Ø1B4 BD ØØ ØØ >        JSR  LGLTST  ZERO (Z) BIT OF C REG.=Ø IF
Ø1B7 26 ØØ    >        BNE  G3       PLAY IS LEGAL.
Ø1B9 CE ØØ ØØ >        LDX  #MES9  IF NOT, PRINT "ILLEGAL"
Ø1BC 8D DØ    >        BSR  TXTOUT
Ø1BE 2Ø EØ    >        BRA  GTVLHP  AND TRY AGAIN.
Ø1CØ          >
Ø1CØ 96 4B    >G3      LDAA LTSTIN+1 STORE VALID LEGAL H PLAY.
Ø1B8 Ø7
Ø1C2 97 45    >        STAA HPLAY
Ø1C4 39       >        RTS
Ø1C5          >
Ø1C5          >*  LEGAL TEST S.R., LGLTST
Ø1C5          >
Ø1C8          >        ORG  $1C8
Ø1C8 96 4B    >LGLTST LDAA LTSTIN+1 Ø AND 7 INPUTS
Ø1B5 Ø1 C8
Ø1CA 27 ØØ    >        BEQ  L1      FROM RAND. NO. GEN. ARE TREATED AS
Ø1CC 81 Ø7    >        CMPA #7       ILLEGAL.
Ø1CE 27 ØØ    >        BEQ  L1
Ø1DØ 91 46    >        CMPA LSTPLA IF TEST PLAY = LAST PLAY,
Ø1D2 27 ØØ    >        BEQ  L1
Ø1D4 9B 46    >        ADDA LSTPLA  OR IF SUM = 7, THEN
Ø1D6 81 Ø7    >        CMPA #7      TEST PLAY IS ILLEGAL.
Ø1D8 39       >L1      RTS          'Z' BIT OF COND'N (C) REG. RETURNS
Ø1CB ØC
Ø1CF Ø8
Ø1D3 Ø4
Ø1D9          >*                    RESULT OF TEST.
Ø1D9          >
              >FP
Ø1D9          >*******************************************
Ø1D9          >*                                         *
Ø1D9          >*   18 WITH A DIE, VSN 2.Ø, CONTINUED     *
Ø1D9          >*                                         *
Ø1D9          >*      R. YOST       79-Ø7-18             *
Ø1D9          >*                                         *
Ø1D9          >*******************************************
Ø1D9          >
Ø1D9          >* S.R.  ADVANCE AND ANALYZE TOTAL  AVAZTO
Ø1D9          >
Ø1EØ          >        ORG  $1EØ
Ø1EØ 7F ØØ 49 >AVAZTO CLR  ENDGAM INILZ END GAME FLAG
Ø146 Ø1 EØ
Ø1E3 CE ØØ ØØ >        LDX  #MESA  PRINT "TOTAL IS "
Ø1E6 8D A6    >        BSR  TXTOUT
Ø1E8 96 46    >        LDAA LSTPLA  GET LAST PLAY
Ø1EA D6 47    >        LDAB HTURN    AND H TURN FLAG
Ø1EC          >*                     IN 'A' AND 'B' REGS.
Ø1EC 9B 44    >        ADDA TOTBCD  ADD LAST PLAY TO BCD TOTAL.
Ø1EE 19       >        DAA
Ø1EF 97 44    >        STAA TOTBCD
Ø1F1 CE ØØ 44 >        LDX  #TOTBCD SET 'X' AS PNTR FOR MKBG S.R.
Ø1F4 BD EØ CA >        JSR  OUT2HS PRINT TOTAL.
Ø1F7 96 46    >        LDAA LSTPLA NOW, ADD LAST PLAY TO
Ø1F9 9B 43    >        ADDA TOTAL    BINARY TOTAL.
Ø1FB 97 43    >        STAA TOTAL
Ø1FD 8Ø 12    >        SUBA #18    IF TOTAL < 18, THEN RETURN.
Ø1FF 2D ØØ    >        BLT  A2
Ø2Ø1 7C ØØ 49 >        INC  ENDGAM  ELSE, SET END GAME FLAG.
Ø2Ø4 4D       >        TSTA          IF TOTAL NOT 18,
Ø2Ø5 27 ØØ    >        BEQ  A4
Ø2Ø7 5D       >        TSTB          AND IF H'S TURN, THEN
Ø2Ø8 27 ØØ    >        BEQ  A3
Ø2ØA CE ØØ ØØ >A1      LDX  #MESB      PRINT "I WIN",
Ø2ØD BD Ø1 8E >        JSR  TXTOUT
Ø21Ø 86 Ø1    >        LDAA #1         AND INCREMENT M'S SCORE IN BCD.
Ø212 9B 42    >        ADDA SCOREM
Ø214 19       >        DAA
Ø215 97 42    >        STAA SCOREM
Ø217 39       >A2      RTS
Ø2ØØ 16
Ø218          >
Ø218 CE ØØ ØØ >A3      LDX  #MESC     IF TOTAL NOT 18, AND IF M'S TURN
Ø2Ø9 ØE
Ø21B BD Ø1 8E >        JSR  TXTOUT     PRINT "YOU WIN"
Ø21E 86 Ø1    >        LDAA #1         AND INCREMENT H'S SCORE IN BCD.
Ø22Ø 9B 41    >        ADDA SCOREH
Ø222 19       >        DAA
Ø223 97 41    >        STAA SCOREH
Ø225 39       >        RTS
```

```
0226            >
0226 5D         >A4     TSTB            ELSE, IF TOTAL = 18,
0206 1F
0227            >*                       AND IF M'S TURN, THEN
0227 27 E1      >       BEQ  A1          AWARD WIN TO MACHINE.
0229 20 ED      >       BRA  A3          ELSE, IF H'S TURN, AWARD
022B            >*                      WIN TO HUMAN.
022B            >
022B            >
022B            >*     SUBROUTINE  REVISE WINTABLE - RVSTBW
022B            >
0230            >       ORG  $230
0230 4F         >RVSTBW CLRA
0168 02 30
0231 97 53      >       STAA MPLAW  RESET WINNING PLAY REG. TO 'NONE' STATE.
0233 97 56      >       STAA WTBLRP CLEAR W.TBLE PTR. HIGH
0235            >*                   BYTE FOR PAGE 0 USE.
0235 9F 54      >       STS  SSTO   SAVE STACK POINTER.
0237 CE 00 01   >       LDX  #1     LOAD TABLE POINTER WITH TRIAL
023A            >*                   PLAY OF 1.
023A 86 26      >       LDAA #WINTBL-1 INLZ W TBLE PNTR LOW BYTE TO
023C 9B 43      >       ADDA TOTAL  CORRESPOND TO CURRENT TOTAL.
023E 97 57      >       STAA WTBLRP+1
0240 9E 56      >       LDS  WTBLRP SET STK PTR TO NEXT ROW OF W. TABLE.
0242 32         >R1     PULA         GET W. TABLE ROW (BYTE) IN 'A'.
0243            >*                   ( THIS IS THE ROW CORRESPONDING TO
0243            >*                   THE CURRENT TOTAL PLUS THE TRIAL
0243            >*                   MACHINE PLAY.)
0243 A4 20      >       ANDA MSKTBL,X MASK WITH LEGAL RESPONSES
0245            >*                   TO M'S TRIAL PLAY.
0245 A7 4B      >       STAA WHRF-1,X STORE RESULT IN TBL. OF WINNING
0247            >*                   H RESPONSES TO M TRIAL PLAYS.
0247 08         >       INX          GET NEXT TRIAL M PLAY;
0248 8C 00 07   >       CPX  #7      IF < 7, REPEAT SCAN FOR LEGAL WINNING
024B 26 F5      >       BNE  R1       H RESPONSES.
024D            >
024D            >* NOW, ADD WINNING M PLAYS FOUND ABOVE TO THE WIN TABLE
024D            >* IN THE ROW CORRESPONDING TO THE CURRENT TOTAL.  LIKE-
024D            >* WISE, DELETE ANY PREVIOUSLY INCORRECTLY DEFINED WIN-
024D            >* ING PLAYS FROM THE SAME ROW.
024D            >
024D 86 20      >       LDAA #$20   SET 6TH BIT OF M TRIAL PLAY PATTERN.
024F 97 40      >       STAA MPTPAT
0251 CE 00 06   >       LDX  #6     SELECT M TRIAL PLAY OF 6.
0254            >*                   (BY COUNTING DOWN, GET SMALLEST
0254            >*                   WINNING PLAY IN MPLAW.)
0254 9E 56      >R2     LDS  WTBLRP SET STK PTR TO CURRENT
0256 34         >       DES          TOTAL ROW (BYTE) OF W. TABLE.
0257 6D 4B      >       TST  WHRF-1,X DID PREVIOUS SCAN DETECT ANY WINNING
0259            >*                   LEGAL H RESPONSES TO TRIAL M PLAY?
0259 26 00      >       BNE  R3     IF NOT, TRIAL M PLAY IS A WINNING PLAY,
025B 32         >       PULA         SO 'OR' THE TRIAL BIT PATTERN INTO THE
025C 9A 40      >       ORAA MPTPAT CURRENT TOTAL ROW OF THE W. TABLE.
025E 36         >       PSHA
025F DF 4A      >       STX  LTSTIN TEST TRIAL PLAY FOR LEGALITY,
0261 9E 54      >       LDS  SSTO    AFTER RESTORING STACK POINTER.
0263 BD 01 C8   >       JSR  LGLTST
0266 27 00      >       BEQ  R4     IF LEGAL, STORE TRIAL PLAY IN
0268 96 4B      >       LDAA LTSTIN+1  MPLAW, OVER ANY PREVIOUS LARGER PLAYS.
026A 97 53      >       STAA MPLAW
026C 20 00      >       BRA  R4     SELECT NEXT TRIAL PLAY.
026E            >
026E 73 00 40   >R3     COM  MPTPAT IF LEGAL WINNING H RESPONSES TO TRIAL
025A 13
0271 32         >       PULA         PLAY WERE DETECTED IN PREVIOUS SCAN,
```

```
0272 94 40      >       ANDA MPTPAT  CLEAR THE BIT (IN CURRENT W. TABLE
0274 36         >       PSHA          ROW) CORRESPONDING TO M TRIAL PLAY.
0275 73 00 40   >       COM  MPTPAT
0278 09         >R4     DEX          SELECT NEXT (LOWER) M. TRIAL PLAY
0267 10
026D 0A
0279 74 00 40   >       LSR  MPTPAT MOVE TRIAL PLAY PATTERN BIT TO
027C            >*                    CORRESPOND TO NEXT M. TRIAL PLAY.
027C 26 D6      >       BNE  R2     IF PATTERN NOT NULL, REPEAT
027E            >*                    W. TABLE REVISION FOR NEXT M. TRIAL PLAY.
027E 9E 54      >       LDS  SSTO   RESTORE STACK POINTER.
0280 39         >       RTS
0281            >
0281            >*   SUBROUTINE  SELECT M. PLAY  - SELMPL
0281            >
0290            >       ORG  $290
0290 BD 00 00   >SELMPL JSR  GNRNPL GET RANDOM NUMBER 0 THRU 7,
0170 02 90
0293            >*                  FOR GOOF DECISION.
0293 27 00      >       BEQ  SP1    IF = 0, GOOF. (WITH SP1, THIS IS
0295            >*                  TURNED OFF. USE SP2 HERE TO TURN ON.)
0295            >
0295 96 53      >SP1    LDAA MPLAW  IF NOT GOOFING, GET WINNING M PLAY.
0294 00
0297 27 00      >       BEQ  SP2    IF THERE WAS NONE, GET RANDOM PLAY
0299 20 00      >       BRA  SP3     AND STORE IN M PLAY REG.
029B            >
029B BD 00 00   >SP2    JSR  GNRNPL  GET RANDOM PLAY,  0 THRU 7.
0298 02
029E 97 4B      >       STAA LTSTIN+1 TEST SELECTED PLAY FOR LEGALITY.
02A0 BD 01 C8   >       JSR  LGLTST
02A3 27 F6      >       BEQ  SP2    IF ILLEGAL, TRY ANOTHER.
02A5 96 4B      >       LDAA LTSTIN+1 ELSE, TRANSFER THE SELECTED PLAY
02A7 97 52      >SP3    STAA MPLAY  TO THE M PLAY REG.
029A 0C
02A9 39         >       RTS
02AA            >
02AA            >*   SUBROUTINE GENERATE RANDOM PLAY - GNRNPL
02AA            >
02B0            >       ORG  $2B0
02B0            >
02B0 CE 00 03   >GNRNPL LDX  #3      COUNT 3 SHIFTS, SO 3 'NEW' BITS WILL
0291 02 B0
029C 02 B0
02B3            >*                    BE GENERATED.
02B3 C6 09      >GR1    LDAB #9      MASK BIT PATTERN TO IMPLEMENT
02B5            >*                    BIT-3 EXOR BIT-0 = 1?
02B5 D4 59      >       ANDB RANUM+1 APPLY MASK TO LOW BYTE OF R.N.
02B7 C1 01      >       CMPB #1      TEST TRUE, SO SET CARRY.
02B9 27 00      >       BEQ  GR2
02BB C1 08      >       CMPB #8      TEST FALSE, SO CLEAR CARRY.
02BD 0C         >       CLC
02BE 26 00      >       BNE  GR3
02C0 0D         >GR2    SEC
02BA 05
02C1 76 00 58   >GR3    ROR  RANUM  ROTATE CARRY INTO MSB OF 2 BYTE R.N.
02BF 01
02C4 76 00 59   >       ROR  RANUM+1
02C7 09         >       DEX          DECREMENT SHIFT COUNTER.
02C8 26 E9      >       BNE  GR1
02CA 96 59      >       LDAA RANUM+1 STORE 3 LSB'S OF R.N. IN 'A', AS
02CC 84 07      >       ANDA #7      RANDOM NUMBER 0 THRU 7.
02CE 39         >       RTS
02CF            >
                >FP
```

Listing 1 continued on page 226

Listing 1 continued:

```
Ø2CF          >******************************************
Ø2CF          >*                                        *
Ø2CF          >*      18 WITH A DIE, VSN 2.Ø, MESSAGES  *
Ø2CF          >*                                        *
Ø2CF          >*     R. YOST,        79-Ø7-18           *
Ø2CF          >*                                        *
Ø2CF          >******************************************
Ø2CF          >
Ø2CF          >*   CURSOR / SCREEN ERASE / CONSTANTS
Ø2CF          >
1Ø16          >CHMEOF EQU  $1Ø16  CURSOR HOME, ERASE SCREEN
ØDØA          >CRLF   EQU  $DØA   CARRIAGE RETURN, LINE FEED
ØØØ4          >ENDST  EQU  4      STRING END SYMBOL FOR MIKBUG PDATA1
ØØ1Ø          >CRHM   EQU  $1Ø    CURSOR HOME
ØØØA          >LNFD   EQU  $A     LINE FEED
ØAØA          >LNFDS  EQU  $AØA   TWO LINE FEEDS
ØØ15          >EOL    EQU  $15    ERASE TO END OF LINE
ØØ16          >EOF    EQU  $16    ERASE FROM CURSOR TO END OF SCREEN
ØØØD          >CRET   EQU  $D     CARRIAGE RETURN
Ø2CF          >
Ø2CF          >*   INSTRUCTIONS - MES1
Ø2CF          >
Ø2DØ          >       ORG  $2DØ
Ø2DØ 1Ø 16    >MES1   FDB  CHMEOF
Ø1Ø7 Ø2 DØ
Ø2D2 ØØ ØØ    >       FDB  Ø
Ø2D4 ØØ       >       FCB  Ø
Ø2D5 48 49 21 >       FCC  31,HI! LET'S PLAY "18 WITH A DIE"!
Ø2D8 2Ø 4C 45
Ø2DB 54 27 53
Ø2DE 2Ø 5Ø 4C
Ø2E1 41 59 2Ø
Ø2E4 22 31 38
Ø2E7 2Ø 57 49
Ø2EA 54 48 2Ø
Ø2ED 41 2Ø 44
Ø2FØ 49 45 22
Ø2F3 21
Ø2F4 ØD ØA    >       FDB  CRLF
Ø2F6 59 4F 55 >       FCC  31,YOU START; CHOOSE ANY NUMBER, 1
Ø2F9 2Ø 53 54
Ø2FC 41 52 54
Ø2FF 3B 2Ø 43
Ø3Ø2 48 4F 4F
Ø3Ø5 53 45 2Ø
Ø3Ø8 41 4E 59
Ø3ØB 2Ø 4E 55
Ø3ØE 4D 42 45
Ø311 52 2C 2Ø
Ø314 31
Ø315 ØD ØA    >       FDB  CRLF
Ø317 54 48 52 >       FCC  29,THRU 6. I DO LIKEWISE, BUT WE
Ø31A 55 2Ø 36
Ø31D 2E 2Ø 49
Ø32Ø 2Ø 44 4F
Ø323 2Ø 4C 49
Ø326 4B 45 57
Ø329 49 53 45
Ø32C 2C 2Ø 42
Ø32F 55 54 2Ø
Ø332 57 45
Ø334 ØD ØA    >       FDB  CRLF
Ø336 43 41 4E >       FCC  31,CAN'T PLAY THE NUMBER THE OTHER
Ø339 27 54 2Ø
Ø33C 5Ø 4C 41
Ø33F 59 2Ø 54
Ø342 48 45 2Ø
Ø345 4E 55 4D
Ø348 42 45 52
Ø34B 2Ø 54 48
Ø34E 45 2Ø 4F
Ø351 54 48 45
Ø354 52
Ø355 ØD ØA    >       FDB  CRLF
Ø357 4A 55 53 >       FCC  31,JUST PLAYED, NOR ITS DIFFERENCE
Ø35A 54 2Ø 5Ø
Ø35D 4C 41 59
Ø36Ø 45 44 2C
Ø363 2Ø 4E 4F
Ø366 52 2Ø 49
Ø369 54 53 2Ø
Ø36C 44 49 46
Ø36F 46 45 52
Ø372 45 4E 43
Ø375 45
Ø376 ØD ØA    >       FDB  CRLF
Ø378 46 52 4F >       FCC  29,FROM 7. TRY TO MAKE THE TOTAL
Ø37B 4D 2Ø 37
Ø37E 2E 2Ø 54
Ø381 52 59 2Ø
Ø384 54 4F 2Ø
Ø387 4D 41 4B
Ø38A 45 2Ø 54
Ø38D 48 45 2Ø
Ø39Ø 54 4F 54
Ø393 41 4C
Ø395 ØD ØA    >       FDB  CRLF
Ø397 4F 46 2Ø >       FCC  26,OF ALL OUR PLAYS HIT 18 ON
Ø39A 41 4C 4C
Ø39D 2Ø 4F 55
Ø3AØ 52 2Ø 5Ø
Ø3A3 4C 41 59
Ø3A6 53 2Ø 48
Ø3A9 49 54 2Ø
Ø3AC 31 38 2Ø
Ø3AF 4F 4E
Ø3B1 ØD ØA    >       FDB  CRLF
Ø3B3 59 4F 55 >       FCC  1Ø,YOUR PLAY.
Ø3B6 52 2Ø 5Ø
Ø3B9 4C 41 59
Ø3BC 2E
Ø3BD ØD ØA    >       FDB  CRLF
Ø3BF ØA       >       FCB  LNFD
Ø3CØ 52 45 41 >       FCC  31,READY TO START? (TYPE Y OR N.)
Ø3C3 44 59 2Ø
Ø3C6 54 4F 2Ø
Ø3C9 53 54 41
Ø3CC 52 54 3F
Ø3CF 2Ø 28 54
Ø3D2 59 5Ø 45
Ø3D5 2Ø 59 2Ø
Ø3D8 4F 52 2Ø
Ø3DB 4E 2E 29
Ø3DE 2Ø
Ø3DF Ø4       >       FCB  ENDST
Ø3EØ          >
Ø3EØ          >*  NEW GAME HEADER - MES2
Ø3EØ          >
Ø3FØ          >       ORG  $3FØ
Ø3FØ 1Ø 16    >MES2   FDB  CHMEOF
Ø123 Ø3 FØ
Ø3F2 ØØ ØØ    >       FDB  Ø
Ø3F4 2Ø 2Ø 2Ø >       FCC  25,       EIGHTEEN WITH A DIE
```

```
Ø3F7 2Ø 2Ø 2Ø
Ø3FA 45 49 47
Ø3FD 48 54 45
Ø4ØØ 45 4E 2Ø
Ø4Ø3 57 49 54
Ø4Ø6 48 2Ø 41
Ø4Ø9 2Ø 44 49
Ø4ØC 45
Ø4ØD ØD ØA    >        FDB  CRLF
Ø4ØF ØA       >        FCB  LNFD
Ø41Ø 2Ø 2Ø 2Ø >        FCC  29,                  GAMES WON
Ø413 2Ø 2Ø 2Ø
Ø416 2Ø 2Ø 2Ø
Ø419 2Ø 2Ø 2Ø
Ø41C 2Ø 2Ø 2Ø
Ø41F 2Ø 2Ø 2Ø
Ø422 2Ø 2Ø 47
Ø425 41 4D 45
Ø428 53 2Ø 57
Ø42B 4F 4E
Ø42D ØD ØA    >        FDB  CRLF
Ø42F 2Ø 2Ø 2Ø >        FCC  28,                  YOU ME
Ø432 2Ø 2Ø 2Ø
Ø435 2Ø 2Ø 2Ø
Ø438 2Ø 2Ø 2Ø
Ø43B 2Ø 2Ø 2Ø
Ø43E 2Ø 2Ø 2Ø
Ø441 2Ø 2Ø 2Ø
Ø444 2Ø 59 4F
Ø447 55 2Ø 4D
Ø44A 45
Ø44B ØD ØA    >        FDB  CRLF
Ø44D 54 4F 54 >        FCC  23,TOTAL IS ØØ.
Ø45Ø 41 4C 2Ø
Ø453 49 53 2Ø
Ø456 3Ø 3Ø 2E
Ø459 2Ø 2Ø 2Ø
Ø45C 2Ø 2Ø 2Ø
Ø45F 2Ø 2Ø 2Ø
Ø462 2Ø 2Ø
Ø464 Ø4       >        FCB  ENDST
Ø465          >
Ø465          >*  YOUR FIRST PLAY?   - MES3
Ø465          >
Ø465          >        ORG  $465
Ø465 ØD ØA    >MES3    FDB  CRLF
Ø134 Ø4 65
Ø467 ØA       >        FCB  LNFD
Ø468 2Ø 2Ø 2Ø >        FCC  25,        YOUR FIRST PLAY?
Ø46B 2Ø 2Ø 2Ø
Ø46E 2Ø 2Ø 59
Ø471 4F 55 52
Ø474 2Ø 46 49
Ø477 52 53 54
Ø47A 2Ø 5Ø 4C
Ø47D 41 59 3F
Ø48Ø 2Ø
Ø481 Ø4       >        FCB  ENDST
Ø482          >
Ø482          >*  ILLEGAL PLAY    - MES9
Ø482          >
Ø482          >        ORG  $482
Ø482 ØD ØA    >MES9    FDB  CRLF
Ø1BA Ø4 82
Ø484 ØØ ØØ    >        FDB  Ø
Ø486 49 4C 4C >        FCC  27,ILLEGAL PLAY! TRY ANOTHER.
Ø489 45 47 41
Ø48C 4C 2Ø 5Ø
```

```
Ø48F 4C 41 59
Ø492 21 2Ø 54
Ø495 52 59 2Ø
Ø498 41 4E 4F
Ø49B 54 48 45
Ø49E 52 2E 2Ø
Ø4A1 Ø4       >        FCB  ENDST
Ø4A2          >
Ø4A2          >*  INVALID PLAY  - MES8
Ø4A2          >
Ø4A2          >        ORG  $4A2
Ø4A2 ØD ØA    >MES8    FDB  CRLF
Ø1AC Ø4 A2
Ø4A4 ØØ       >        FCB  Ø
Ø4A5 49 4E 56 >        FCC  31,INVALID PLAY! PLAY 1 THRU 6. ?
Ø4A8 41 4C 49
Ø4AB 44 2Ø 5Ø
Ø4AE 4C 41 59
Ø4B1 21 2Ø 5Ø
Ø4B4 4C 41 59
Ø4B7 2Ø 31 2Ø
Ø4BA 54 48 52
Ø4BD 55 2Ø 36
Ø4CØ 2E 2Ø 3F
Ø4C3 2Ø
Ø4C4 Ø4       >        FCB  ENDST
Ø4C5          >
Ø4C5          >*  TOTAL IS   -   MESA
Ø4C5          >
Ø4CE          >        ORG  $4CE
Ø4CE 1Ø       >MESA    FCB  CRHM
Ø1E4 Ø4 CE
Ø4CF ØA ØA    >        FDB  LNFDS
Ø4D1 ØA ØA    >        FDB  LNFDS
Ø4D3 54 4F 54 >        FCC  9,TOTAL IS
Ø4D6 41 4C 2Ø
Ø4D9 49 53 2Ø
Ø4DC Ø4       >        FCB  ENDST
Ø4DD          >
Ø4DD          >*  YOU WIN!     -  MESC
Ø4DD          >
Ø4DD          >        ORG  $4DD
Ø4DD 2E 2Ø 59 >MESC    FCC  11,. YOU WIN!
Ø4EØ 4F 55 2Ø
Ø4E3 57 49 4E
Ø4E6 21 2Ø
Ø219 Ø4 DD
Ø4E8 Ø4       >        FCB  ENDST
Ø4E9          >
Ø4E9          >*  I WIN!    -   MESB
Ø4E9          >
Ø4EA          >        ORG  $4EA
Ø4EA 2E 2Ø 2Ø >MESB    FCC  11,.  I  WIN!
Ø4ED 49 2Ø 2Ø
Ø4FØ 57 49 4E
Ø4F3 21 2Ø
Ø2ØB Ø4 EA
Ø4F5 Ø4       >        FCB  ENDST
Ø4F6          >
Ø4F6          >*  NEW GAME?    -  MES4
Ø4F6          >
Ø4F6          >        ORG  $4F6
Ø4F6 ØA       >MES4    FCB  LNFD
Ø15A Ø4 F6
Ø4F7 ØD ØA    >        FDB  CRLF
```

Listing 1 continued on page 228

Listing 1 continued:

```
Ø4F9 15       >        FCB   EOL
Ø4FA 4E 45 57 >        FCC   23,NEW GAME? ("Y" OR "N")
Ø4FD 2Ø 47 41
Ø5ØØ 4D 45 3F
Ø5Ø3 2Ø 28 22
Ø5Ø6 59 22 2Ø
Ø5Ø9 4F 52 2Ø
Ø5ØC 22 4E 22
Ø5ØF 29 2Ø
Ø511 Ø4       >        FCB   ENDST
Ø512          >
Ø512          >*    THANKS,  ETC.   -  MES5
Ø512          >
Ø512          >        ORG   $512
Ø512 ØD       >MES5    FCB   CRET
Ø114 Ø5 12
Ø513 54 48 41 >        FCC   28,THANKS FOR PLAYING. HOPE YOU
Ø516 4E 4B 53
Ø519 2Ø 46 4F
Ø51C 52 2Ø 5Ø
Ø51F 4C 41 59
Ø522 49 4E 47
Ø525 2E 2Ø 48
Ø528 4F 5Ø 45
Ø52B 2Ø 59 4F
Ø52E 55
Ø52F ØD ØA    >        FDB   CRLF
Ø531 45 4E 4A >        FCC   24,ENJOYED IT AS MUCH AS I.
Ø534 4F 59 45
Ø537 44 2Ø 49
Ø53A 54 2Ø 41
Ø53D 53 2Ø 4D
Ø54Ø 55 43 48
Ø543 2Ø 41 53
Ø546 2Ø 49 2E
Ø549 ØD ØA    >        FDB   CRLF
Ø54B 53 45 45 >        FCC   14,SEE YOU LATER!
Ø54E 2Ø 59 4F
Ø551 55 2Ø 4C
Ø554 41 54 45
Ø557 52 21
Ø559 Ø4       >        FCB   ENDST
Ø55A          >
Ø55A          >*    MY PLAY IS   -  MES6
Ø55A          >
Ø55A          >        ORG   $55A
Ø55A ØA       >MES6    FCB   LNFD
Ø17C Ø5 5A
Ø55B ØD ØA    >        FDB   CRLF
Ø55D 16       >        FCB   EOF
Ø55E ØØ ØØ    >        FDB   Ø
Ø56Ø ØØ ØØ    >        FDB   Ø
Ø562 4D 59 2Ø >        FCC   11,MY PLAY IS
Ø565 5Ø 4C 41
Ø568 59 2Ø 49
Ø56B 53 2Ø
Ø56D Ø4       >        FCB   ENDST
Ø56E          >
Ø56E          >*    YOUR PLAY?   -  MES7
Ø56E          >
Ø56E          >        ORG   $56E
Ø56E 2E       >MES7    FCC   1,.
Ø188 Ø5 6E
Ø56F ØA ØA    >        FDB   LNFDS
Ø571 2Ø 2Ø 59 >        FCC   13,  YOUR PLAY?
Ø574 4F 55 52
Ø577 2Ø 5Ø 4C
Ø57A 41 59 3F
Ø57D 2Ø
Ø57E Ø4       >        FCB   ENDST
Ø57F          >
Ø57F          >
Ø57F          >        END

<<< UNRESOLVED ITEMS >>>
```

```
<<< SYMBOLS >>>

A1   020A  A2   0217  A3   0218  A4   0226  AVA0 01E0
CHMF 1016  CONL E0E3  CRET 000D  CRHM 0010  CRLF 0DCA
ENDM 0049  ENDT 0004  EOF  0016  EOL  0015  G1   01AB
G2   01B2  G3   01C0  GNRL 02B0  GR1  02B3  GR2  02C0
GR3  02C1  GTVP 01A0  HPLY 0045  HTUN 0047  I1   007A
I2   0084  INEE E1AC  INIZ 005D  L1   01D8  LGLT 01C8
LNFD 000A  LNFS 0A0A  LSTA 0046  LTSN 004A  M1   0113
M2   011B  M3   0138  M4   0145  M5   0167  M6   0187
MES1 02D0  MES2 03F0  MES3 0465  MES4 04F6  MES5 0512
MES6 055A  MES7 056E  MES8 04A2  MES9 0482  MESA 04CE
MESB 04EA  MESC 04DD  MPLW 0053  MPLY 0052  MPTT 0040
MSKL 0020  OUTR E06B  OUTS E0CA  PDA1 E07E  R1   0242
R2   0254  R3   026E  R4   0278  RANM 0058  RVSW 0230
SCNG 0048  SCOH 0041  SCOM 0042  SELL 0290  SP1  0295
SP2  029B  SP3  02A7  SSTO 0054  TOTD 0044  TOTL 0043
TXTT 018E  WHRF 004C  WINL 0027  WTBP 0056  C
```

Table 2: *Symbols for the Eighteen with a Die learning program (written for the Motorola M6800 processor) shown in listing 1.*

Text continued from page 221:

for every total having winning moves. (Some totals, including zero, have none.)

Using the goof feature, and if the human does not err and seizes every opportunity to win, the game becomes a game of luck. The random plays made by the machine *may* be winning plays, and a sequence of winning plays found at random is not impossible. With the goof feature activated, the machine will sometimes surprise you by playing the very first game of a series faultlessly.

The game can readily be extended to a goal total greater than eighteen. Multiples of nine assure that no winning play is available to the first player. Longer games will slow the learning process; not only will each game be longer, but the propagation of "good" information from the end of the win table to its beginning will require many more games. Another elaboration could be a "brain" display similar to the one that I implemented in my mechanical machine, GLIM. ■

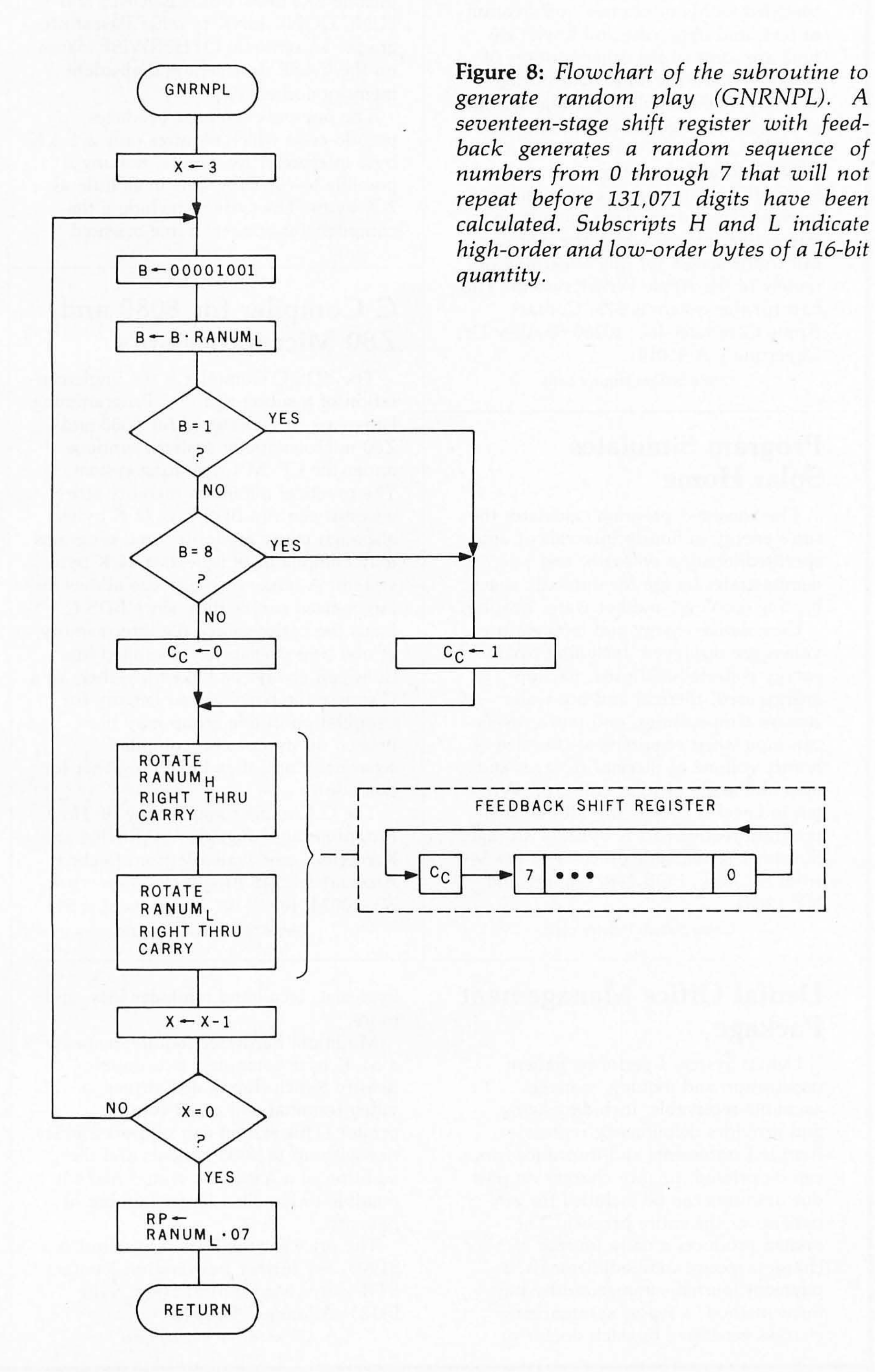


Figure 8: *Flowchart of the subroutine to generate random play (GNRNPL). A seventeen-stage shift register with feedback generates a random sequence of numbers from 0 through 7 that will not repeat before 131,071 digits have been calculated. Subscripts H and L indicate high-order and low-order bytes of a 16-bit quantity.*

REFERENCES

1. Gardner, Martin, "Mathematical Games," *Scientific American,* Volume 206, Number 3, March 1962, page 138.
2. Gardner, Martin, *The Unexpected Hanging,* Simon and Schuster, New York, 1969.
3. Mott-Smith, Geoffrey, *Mathematical Puzzles for Beginners and Enthusiasts* The Blakistone Co, Philadelphia, 1946.
4. Nico, Willard I, "Shooting Stars," BYTE, Volume 1, Number 9, May 1976, page 42.
5. Wier, Robert R, "Hexpawn: A Beginning Project in Artificial Intelligence," BYTE, Volume 1, Number 3, November 1975, page 36.

What's New?

SOFTWARE

Apple Writer — A Low-Cost Text Editor for Apple II Users

Using the Apple Writer, a document needs to be typed into the computer only once; corrections, text additions and the rearrangement of text can be accomplished easily and quickly. Automatic search and replacement for specified words or phrases, justification of text, and uppercase and lowercase type are some of the other features of Apple Writer. The 48 K byte storage capacity of the Apple II permits storage of at least 12 pages of text in each on-line file.

The package consists of two master 5-inch floppy disks and an operating manual. The floppy disks include an interactive tutorial which the user can call to the screen for quick learning or review of the Apple Writer system. The cost for the system is $75. Contact Apple Computer Inc, 10260 Bandley Dr, Cupertino CA 95014.

Circle 562 on inquiry card.

Program Simulates Solar Home

The Sunsim-1 program calculates the sun's energy in hourly intervals at any specified location on earth, and demonstrates its use for domestic space heating, cooling, and hot water heating.

Cumulative energy and temperature values are displayed, including solar energy collected and used, backup energy used, thermal and hot water storage temperatures, and more. Users can input their requirements for size of home, volume of thermal storage, and area and angle of solar collector. Written in Level II BASIC for TRS-80 this program requires 16 K bytes of storage. Sunsim 1 is available on cassette for $49 from Solartek, POB 298, Guilderland NY 12084.

Circle 563 on inquiry card.

Pascal Compiler for the 6800

Dynasoft Pascal is a subset of standard Pascal intended for cassette-based microcomputers that cannot support full-scale implementations such as UCSD Pascal. It includes the control structures of standard Pascal and supports most of the data types. Language extensions include EXTERN, PROCEDUREs and FUNCTIONs, LINK to other Pascal programs, an optional OTHERWISE clause on the CASE statement and absolute memory addressing.

The one-pass compiler produces pseudo-code which requires only a 1.3 K byte interpreter to execute, making it possible to run programs in as little as 2 K bytes. The system, including the compiler, interpreter, a line-oriented editor, and system supervisor, occupies little more than 7 K bytes of memory and compiles a 2000-character source program in 12 K bytes of memory.

Price for the basic cassette version, with manual, is $35, from Dynasoft Systems, POB 51, Windsor Junction, North Saskatchewan B0N 2V0 CANADA.

Circle 564 on inquiry card.

C Compiler for 8080 and Z80 Microprocessors

The BDS C Compiler is the implementation of a subset of the C Programming Language. It is designed for 8080 and Z80 microcomputer systems running under the CP/M 1 operating system. The practical minimum memory size necessary to run BDS C is 32 K bytes, although many modestly sized programs may compile in as little as a 24 K byte system. A larger memory size allows for larger sized source files, since BDS C loads the entire source file into memory at one time. Separately compiled functions can always be linked together, so a C source file which is too lengthy for compilation in one group may be broken up into pieces, compiled separately, and then linked together for execution.

The C Compiler and a copy of *The C Programming Language*, by Ritchie and Kernighan, are available from Lifeboat Associates, 2248 Broadway, New York NY 10024, for $110. The manual is $15.

Circle 565 on inquiry card.

LISP Interpreter for Apple II

This new LISP system features a built-in prettyprinter and LISP editor, both written in LISP, along with prompts that make it clear that LISP is taking in an expression and returning its value. Errors are trapped by the interpreter, and a full trace-back can be printed. Owl LISP has eliminated the PROG pseudofunction, yet defines local variables by using an extended syntax which allows for optional and local variables with default values. Owl LISP also provides a LOOP, WHILE, and UNTIL construction to allow for iterative programming. PEEK, POKE and CALL are provided to access Apple graphics and other functions. String processing can be carried out using IMPLODE and EXPLODE which convert between character strings and lists.

The system consists of about 6 K bytes of code, 300 bytes of garbage collector work space and 4 K bytes of predefined LISP work space. LISP costs £40 from Owl Computers, 41 Stortford Hall Park, Bishops Stortford, Hertfordshire, CM23 5AJ ENGLAND.

Circle 566 on inquiry card.

Dental Office Management Package

Dental System I performs patient registration and inquiry, manages accounts receivable, including aging, and provides delinquency reports. Itemized statements and insurance forms can be printed, finance charges on past due amounts can be included for any patient, or the entire practice. The system produces a daily journal of charges, receipts and adjustments, a payment journal summarized by payment method, a report summarizing charges generated by each doctor or hygienist, recall and reminder lists, and more.

Minimum hardware requirements are a 64 K byte computer, two double-density 8-inch floppy disk drives, a video terminal and a 132-column printer. This system can support a practice with up to 4000 patients and the addition of a hard disk would make it possible to handle a larger number of patients.

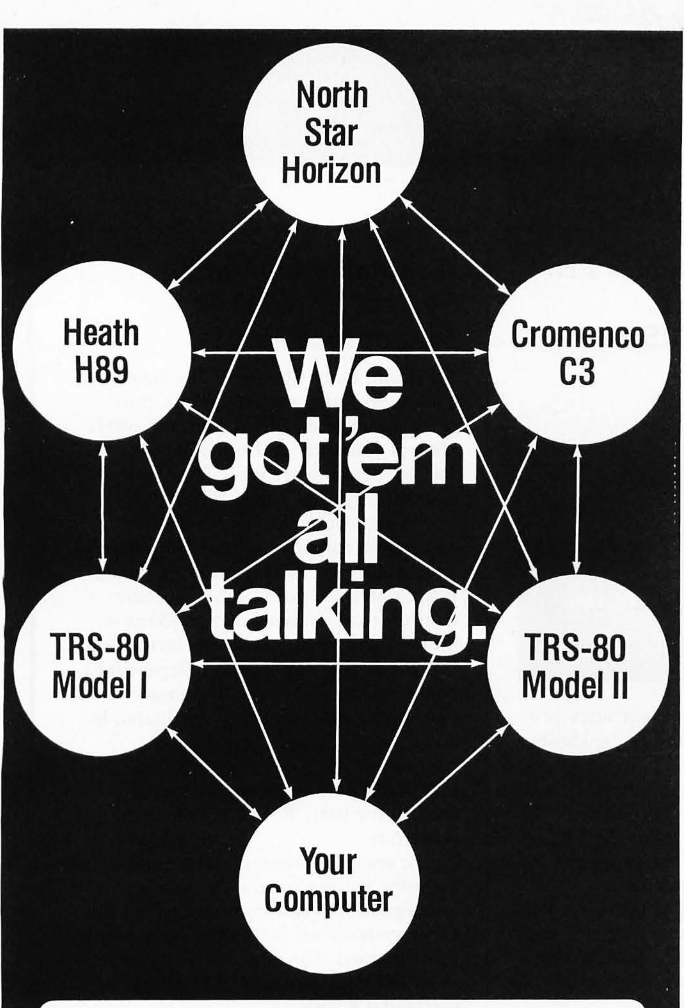
The price for the Dental System I is $1995. For further information, contact STR Corp, 5455 Buford Hwy, Suite B-123, Atlanta GA 30340.

Circle 567 on inquiry card.

Where Do New Products Items Come From?

The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgement the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first in first out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

Circle 199 on inquiry card.



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Circle 200 on inquiry card.

What's New?

SOFTWARE

Music System for Apple II

Micro Music Inc, University Plaza, Suite 8, 309 W Beaufort, Normal IL 61761, has released Micro Composer, an Apple II compatible music-system that allows the user to enter, display, edit, and play music with up to four voices in a 4-octave range. The program allows the user to see all four voices as music is played; enter music by a coding system which keeps track of rhythmic durations, program pitch, rhythm and timbre; choose from seven tone colors for each voice or create tone colors; and has seven preset timbres. Micro Composer comes with a manual, software, and a music card for the Apple II extension slot and is connected to an 8 ohm speaker. Memory requirements are 32 K bytes for the cassette-based system and 48 K bytes for the disk-based system. The price for the package is $220.

Circle 568 on inquiry card.

MMSForth for the TRS-80

Forth is a structured language similar to Pascal except that, in Forth, the programmer defines additional commands as they are needed. The MMSForth System Diskette supplies reliable disk I/O, virtual memory, double precision integer math, in-line editing, string handling and arrays, and user called disk and tape I/O. MMSForth includes full source code for the majority of MMSForth which is written in Forth. Speed is approximately half that of assembler code, while development is usually much less than half.

This system costs $64.95 from Miller Microcomputer Services, 61 Lake Shore Rd, Natick MA 01760.

Circle 569 on inquiry card.

Radio Shack Has Variety of Software for TRS-80 Systems

Radio Shack's programs come on cassette and 5-inch floppy disks for the TRS-80 systems. Among the new programs available are a General Ledger I, an Inventory Control System, Statistical Analysis, Real Estate, a Level-I BASIC course that teaches the user how to program, and several advanced programming aids. Radio Shack also has a number of computer games and novelty programs for the TRS-80. For further information on Radio Shack TRS-80 software or products, contact the Radio Shack Computer Customer Service, 205 NW 7th St, Ft Worth TX 76106.

Circle 570 on inquiry card.

Hard Copy Graphics Program for the PET, Apple II, and TRS-80



West Coast Consultants software provides users with full graphics capability for Houston Instrument's Hiplot plotter. Programs that drive the plotter through an RS-232 interface are currently available on tape cassette for the PET, Apple II, and TRS-80. The programs are written in BASIC and require a minimum of 16 K bytes of memory. For further information, contact West Coast Consultants, 1775 Lincoln Blvd, Tracy CA 95376. The prices are $50 and $75 for the programs.

Circle 571 on inquiry card.

Adaptable Operating System for 6809 Microprocessor

Percom Data Company has developed a 6809 operating system for the company's new SS-50 bus-compatible 6809 control computer and other 6809 microprocessing systems. The 1 K byte operating system, called PSYMON, includes eight monitor-type commands and fifteen callable utilities. Hardware adaptability is easy because interfacing is accomplished with simple, specific device driver routines that reference a table of parameters called a Device Control Block (DCB) which is independent of the operating system. Command expansion or modification is facilitated by a feature that allows user-written routines in read-only memory to alter PSYMON pointers and enhance or modify the basic PSYMON command repertoire.

The erasable-programmable read-only memory version for the Percom SBC/9 sells for $39.95 and the versions for the other systems sell for $69.95 including a users manual. For information, contact Percom Data Company, 211 N Kirby, Garland TX 75042.

Circle 572 on inquiry card.

Pascal Software Compiler for the 1802 Microprocessor

The new GR-Pascal compiler runs with a minimum of 20 K bytes of programmable memory plus a floppy disk system and utilities. Minimum target systems can be from 2 K bytes upwards of program code, including full 16-bit arithmetic package for signed integer variables. The compiler is written in Pascal and features a provision for assembler code, hexadecimal numbers, byte variables, interrupt procedures and disk input/output (I/O) facilities. A typical 200-line Pascal program will compile into 3 K bytes of programmable memory, and processing speed is increased by a factor of 3 to 4 by restricting variables to signed integers with 16-bit accuracy.

The compiler comes on an 1802 circuit in 2 K bytes of read-only memory on-board with 64 K bytes of programmable memory and sells for £40. For more information, contact The Golden River Co Ltd, Telford Rd, Bicester, Oxfordshire, OX6 0UL ENGLAND.

Circle 573 on inquiry card.

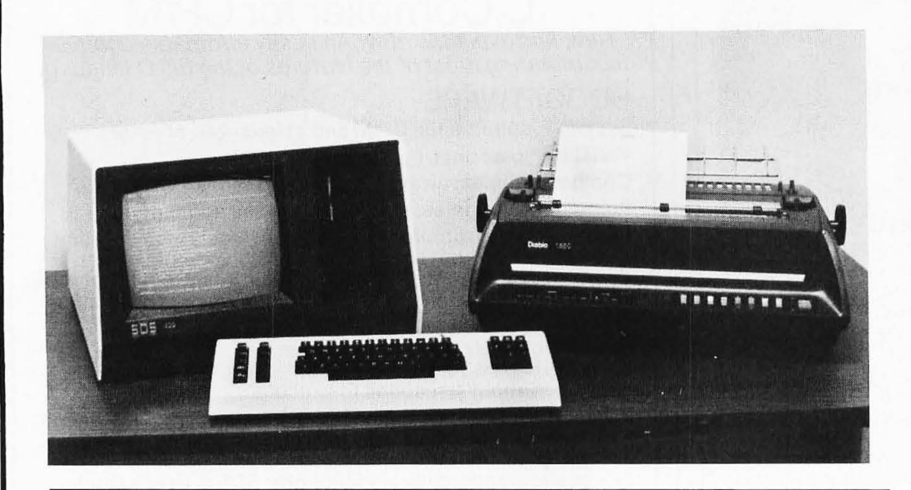
Data Base Management System for Microcomputers

This data base management system (DBMS) runs on 8 to 16 K bytes of read-only memory for Z80, 8080, and 6502 systems. This system provides a full network capability and generalizes some features of the CODASYL approach. The Data Definition Language Analyzer/Editor and Data Manipulation Language permit many-to-many-set relationships. Full data base security is maintained by providing read and write access levels for all record types, items, and set relationships. A common data base is maintained in order that no data need be duplicated in different files, and different applications can be supported in the one data base. Routines are callable from host languages and have input/output (I/O) and host language interface routines isolated for adaption to North Star, CP/M, and TRS-80 operating systems.

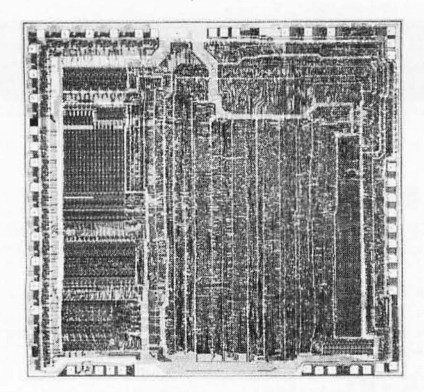
The user's manual and sample application programs are included in the package which costs about $800. For more information, contact Micro Data Base Systems Inc, POB 248, Lafayette IN 47902.

Circle 574 on inquiry card.

SYSTEMS



AMD Delivers the AmZ8000 System



The AmSYS 8/8 floppy disk-based system, designed to support the AmZ8000 processor in both hardware and software, supports the 8080, 8085 and Z80 microprocessors also. Its basic configuration contains 32 K bytes of memory, two floppy disk drives, and multiple serial and parallel input/output (I/O) ports. Software support includes a disk operating system; macroassembler for the AmZ8000; translators from 8080, 8085 and Z80 code to AmZ8000 code; Pascal compiler for the AmZ8000 and a variety of software packages. Prices start at $7450. AMD also has the AMC 96/4016 Evaluation Board, which incorporates the AmZ8002, 8 K bytes of programmable memory, twenty-four parallel I/O lines, two RS-232 serial I/O ports, 12 K bytes of erasable-programmable read-only memory sockets, system clock and resident monitor for $975.

Contact Advanced Micro Devices Inc, 901 Thompson Pl, Sunnyvale CA 94086.

Circle 591 on inquiry card.

Multiprocessor S-100 CP/M Compatible Computer



The Discovery Computer System MP Series A, from Action Computer Enterprise Inc, 75 W Green St, Pasadena CA 91105, features an 8080 microprocessor with 32 K bytes of programmable memory (expandable to 64 K bytes), two serial and two parallel input/output (I/O) ports per processor, a separate S-100 bus for each processor, dual 8-inch floppy disk drives, a video terminal with 24 lines by 80 columns display, 128 upper and lowercase ASCII characters, and an optional printer. Up to 4-user processors can be configured within a single chassis with the ability to expand through auxiliary mainframes and processors.

The Distributed Processing Operating System (DPOS) contains CP/M and supervises reading and updating of files, provides write protection on a disk basis, and prevents incorrect interleaving of file updates. CBASIC-II is provided as the standard user language.

Single-user systems, expandable to multiuser capabilities, start at $3000. A complete four-user computer can be purchased for $11,000. Kits are also available.

Circle 592 on inquiry card.

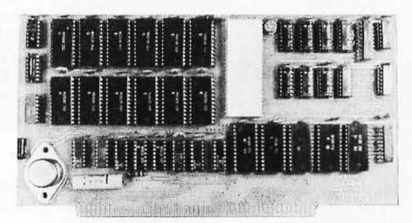
Inexpensive Word Processor Capable of Powerful Formatting and Text Editing

The SDS 420 consists of a video display, keyboard, floppy disk storage that will store 1.2 M bytes of memory, computer, and printer. In addition to standard formatting, the SDS 420 word processor has instructions for right justification, underline, bold text, include a file, indent, exdent, columns, decimal alignment, headings, footings, subscripts and superscripts. The 12-inch screen will display 25 lines of 80 characters per line with variable speed scrolling. The printer will print up to 96 standard characters at 45 characters per second.

The system retails for under $12,000 from Scientific Data Systems, 12640 Beatrice St, Los Angeles CA 90066.

Circle 590 on inquiry card.

Separate BASIC Computer for S-100 Systems



The DLX-10 is a single-board computer that executes BASIC directly in high-speed hardware from 5 to 10 times faster than 8080 systems or 2 to 5 times faster than Z80 systems. It does not replace the microprocessor but functions as a separate BASIC computer. It can boost an S-100 bus microcomputer system into the performance range of a minicomputer.

The DLX-10 runs independently of the main processor and accesses memory as a direct memory access (DMA) device. It runs in parallel to the existing processor, has a stack architecture, and utilizes on-board programmabe memory to hold intermediate computations.

BASIC source language programs are translated by software to relocatable BASIC stack-machine object code and are then executed by the DLX-10.

The DLX-10 comes with software to run Northstar BASIC or CBASIC for $1250 from Alasda Computer Systems, 12759 Poway Rd, Poway CA 92064.

Circle 593 on inquiry card.

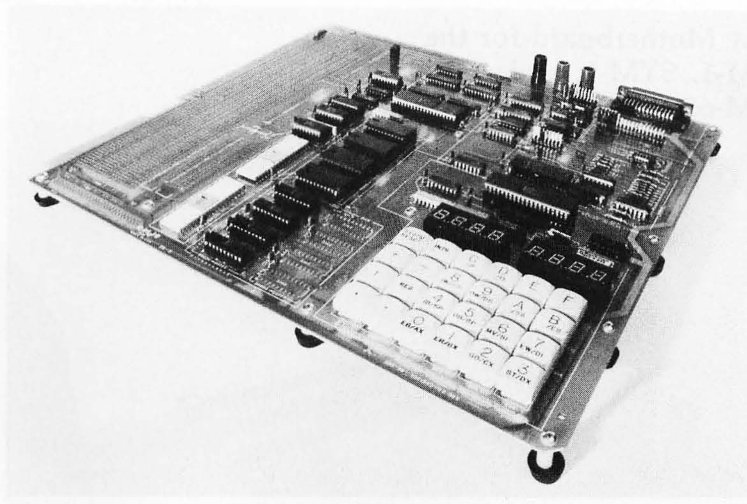
What's New?

SYSTEMS

Microcomputer Kit with 8086 Processor

The Intel SDK-86 is a complete 8086 microcomputer system on a board with memory and I/O (input/output) systems in kit form. This stand-alone 16-bit microcomputer allows designers to obtain hands-on experience with Intel's 8086 16-bit HMOS microprocessor, which offers ten times the processing power of the 8080 processor.

Included in the kit is an 8086 processor; 8 K bytes of 2316 or 2716-type read-only memory; 2 K bytes (expandable to 4 K bytes) of 2142-type programmable memory; 48 parallel I/O lines (implemented through two 8255A programmable peripheral interface devices); an RS-232 or current loop serial I/O structure (implemented via an 8251A universal synchronous/asynchronous receiver-transmitter); selectable data rate from 110 to 4800 bits per second (bps); TTL-compatible bus signals and parallel I/O signals; 24-key hexadecimal data and control keyboard; 8-digit hexadecimal display and control (using an 8279 programmable keyboard and display controller); and 256 vectored interrupts.



The 2 K bytes of 2142-type programmable memory can be doubled by implementing additional devices in the positions provided. There is room for 8 K bytes of program instructions using either or both of the keyboard and terminal software monitors included in the kit. There is a fully buffered system bus. Programs and data may be entered three ways: from the built-in keyboard; through a built-in serial communications interface; or via cable (SDK-C86) from any Intellec Microcomputer Development System.

A complete design library is provided with the kit. This library includes both the assembly and user manual, plus an MCS-86 user manual and 8086 assembly language reference manual. The SDK-86 microcomputer kit is priced at $780. For further information, contact Intel Corp, 3065 Bowers Ave, Santa Clara CA 95051.

Circle 594 on inquiry card.

Personal Computer Introduced by Texas Instruments

Texas Instruments has introduced a personal computer featuring easy-to-use computing power for personal finance, home management, family entertainment and education. Designated the Model TI-99/4, the system consists of a console with 16 K bytes of programmable memory, a wide range of sound effects, sixteen colors for graphic display, a powerful extended BASIC programming language, and a 13-inch color video monitor.



At the heart of the TI-99/4 is a library of Texas Instruments Solid State Software command modules. These command modules allow users instant program accessibility. Solid State Software command module titles include: Demonstration, Diagnostic, Early Learning Fun, Beginning Grammar, Number Magic, Video Graphs, Home Financial Decisions, Household Budget Management, Video Chess, Football, Physical Fitness, Speech Construction, Investment Analysis, Personal Record Keeping, Statistics, Early Reading, and Tax and Investment Record Keeping.

Among peripheral accessories offered is a Solid State Speech synthesizer with a price of $150. By building a basic vocabulary into the language system, home programmers can place audible messages in their programs. The speech synthesizer module has a 200-word vocabulary and plugs into the console. Speech can be written into programs using BASIC programming language. Future command modules will call up spoken words automatically.

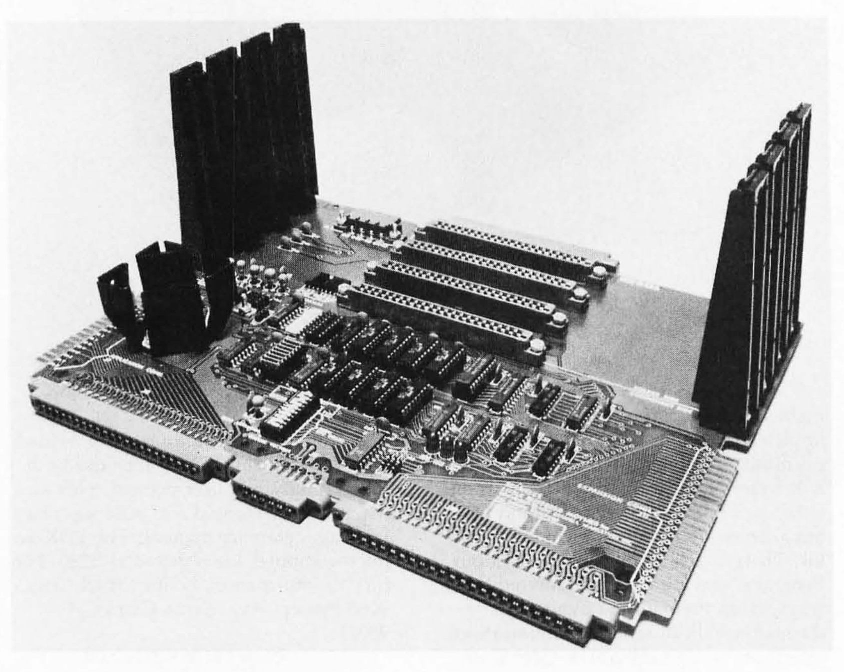
TI BASIC is a full floating point, 13-digit expanded version of BASIC that is fully compatible with ASCII and the BASIC specification of the American National Standards Institute. TI BASIC includes a full complement of 24 BASIC statements, 14 commands, color graphics, and sound and music over four full octaves. A *Beginner's BASIC Guide* for self-teaching comes with the TI-99/4. For users knowledgeable about programming, McGraw-Hill has published *Programming BASIC With the TI Home Computer*, a book by Herbert Peckham.

Remote controls are offered as accessories to the TI-99/4. Two of these controls may be connected to the computer at the same time. Each includes a multiposition (360°) rotary lever with a side-mounted pushbutton. Other accessories offered by Texas Instruments include: a printer, disk storage, and an RS-232 interface device for connecting the computer to other electronic devices.

The price for the TI-99/4 system is $1150. Solid State Software command modules carry prices ranging from $19.95 to $69.95 each. For further information, contact Texas Instruments Inc, Consumer Relations, Attn TI-99/4, POB 53, Lubbock TX 79408.

Circle 595 on inquiry card.

New Motherboard for the KIM-1, SYM-1, and AIM-65



The Little Buffered Mother motherboard incorporates 4 K bytes of programmable memory on the motherboard itself, which, when used with either the SYM-1 or AIM-65, gives the user a total of 8 K bytes of contiguous programmable memory (5 K contiguous on the KIM-1). The motherboard also has regulators for the on-board logic and has the power required for all three microprocessor boards, except the +24 V for the AIM printer.

The unit is available for $139 without programmable memory or for $189 with 4 K bytes of programmable memory. Optional boards for the Little Buffered Mother include programmable memory and a programmer, parallel input/output (I/O), and disk controller.

For more information, contact Seawell Marketing, 315 NW 85th St, Seattle WA 98117.

Circle 596 on inquiry card.

High-Capacity Hard Disk Drive for S-100 Systems

MicroAge has introduced the Fujitsu M2201 Drive with S-100 bus controller for North Star Horizon systems. This system allows accessing up to 40 M bytes of disk storage per drive with the capability of adding up to 4 drives per system. The M2201 was developed with the advent of a new type of direct memory access (DMA) disk controller board capable of very high-speed data transfer. A 2400 RPM rotation combined with a quick seek time and relatively low latency time give the M2201 an average access time of 30 ms.

The system is available for $9995. For more information, contact MicroAge Wholesale, 1425 W 12th Pl, Tempe AZ 85281.

Circle 597 on inquiry card.

Low-Cost Peripheral Accepts Hand-Printed Characters

With the PrestoDigitizer tablet, users can communicate with their computers through ordinary hand-printed characters. Stroke direction and sequence are the parameters which are transmitted to the computer that allow it to recognize the user's style of hand-printed characters. The learning and recognition algorithms fit in approximately 2 K bytes of memory. Versions of the tablet are available for several popular computers. The tablets can recognize the entire uppercase alphabet, numerals, and many punctuation marks. The PrestoDigitizer retails for $48.50, including software, from Innovision, POB 1317, Los Altos CA 94022.

Circle 598 on inquiry card.

8-Inch Fixed Disk Drive Series Offers Low Cost Per Megabyte

An 8-inch Winchester fixed disk drive series that offers 5 and 10 M bytes at a low cost has been introduced by Shugart, 435 Oakmead Pky, Sunnyvale CA 94086. Specifications include a capacity of 5.33 M bytes per drive for the SA1002 and 10.67 M bytes for the SA1004; formatted capacity is 4.2 and 8.4 bytes, respectively. Transfer rate for each type is 4.34 M bits per second. Average access time is 70 ms. The Winchester drives offer the same environmental specifications as the standard 8-inch floppy disk drive. Mean time between failure (MTBF) is 8000 power-on hours of typical usage. Optional data separator and controller printed circuit boards are available.

Price for the SA1002 in single quantities is $1600 and $1980 for the SA1004.

Circle 599 on inquiry card.

MCD Consulting Introduces the Bionic Voice

Designed around a Computalker Consultants CT-1 Speech Synthesizer, the Bionic Voice uses English language design. Knowledge of phonemes or phonetic alphabet is not required. Predefined dictionaries are provided, and custom dictionary entries may be added. Rapid conversations are possible, because of the English language design. The Bionic Voice can be operated like a conventional language or spelling board. All numerals, letters of the alphabet, and any words or phrases defined on the keyboard may be vocalized instantly as the keys are depressed. There are no commands or codes to memorize nor is knowledge of computers necessary.

To upgrade to a version of the Bionic Voice that has more capability, a simple change of keyboard and computer program can be made.

The Bionic Voice may be used as a voice response for nonvocal or nonverbal individuals; for educational and instructional applications in speech pathology and linguistics; and as a foreign language translator. The Bionic Voice is not limited to voice synthesis. It may be applied to other computer functions. The price ranges between $2700 and $3500 depending on necessary modifications.

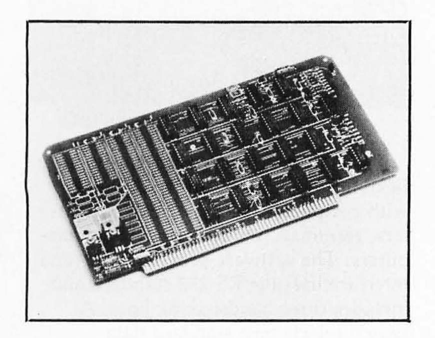
For further information about the Bionic Voice, contact MCD Consulting, 8306 Selleck, 600 N 15th St, Lincoln NE 68508.

Circle 600 on inquiry card.

What's New?

PERIPHERALS

Video Digitizer Allows Display and Storage of Computer Generated Images



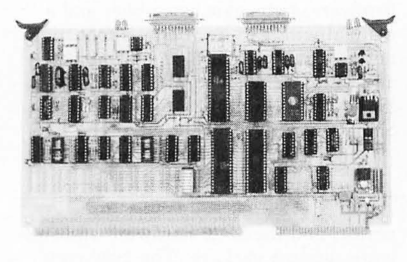
This fast-scan video digitizer can be utilized in consumer environments and in medical, security and other special-purpose applications requiring image storage and analysis.

This device, for S-100 bus computers, converts output from the video camera (or other source of composite video) into 8-bit gray scale digital information. Maximum horizontal resolution is approximately 700 points per line and vertical resolution is 480 lines per image. Data can be transferred via software to either a memory mapped high-resolution video board or to main memory. A driver program, implementing sixteen shades of gray, is included for controlling the board, displaying images on a high-resolution video board, storing images on disk and printing images on a matrix printer.

The price for the video digitizer is $175, and it is available from Vector Graphic Inc, 31364 Via Colinas, Westlake Village CA 91361.

Circle 601 on inquiry card.

Digital Controller for Touch Screen Digitizer

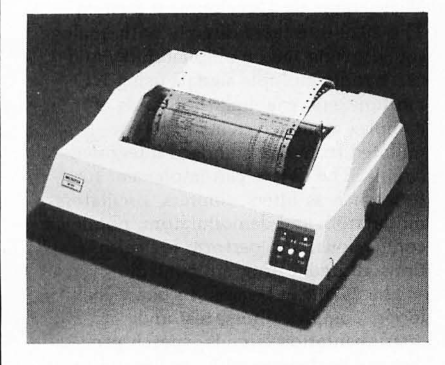


The TSD Touch Screen Digitizer enables untrained personnel to gain access to a data base by simply touching the screen with a finger. The controller provides an interface between the touch screen and other computer equipment. The controller provides all timing signals required by the screen; measures the time delay between the transmitted signal and the reflected signal from an object touching the glass, which allows the resulting data to be adjusted to overlay the display behind the touch screen; processes and filters the echo times to produce clean X,Y position data; and formats the X,Y data into either parallel or serial form.

It is available from TSD Display Products Inc, 35 Orville Dr, Bohemia NY 11716, for $2000.

Circle 602 on inquiry card.

The Microtek MT-80 Printer



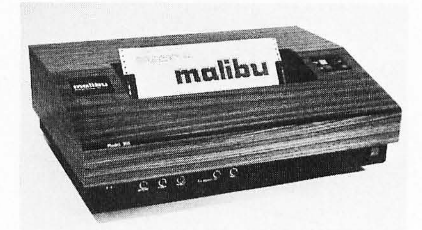
The MT-80 series printer supports the full uppercase and lowercase 96-character ASCII set in three software selectable fonts on original plus three copies. The printer contains a 240-character buffer, with optional data buffers to 4 K available in 1 K increments. A self-diagnostic program is automatically run on power up. Life expectancy of the print head is 100 million characters and mean time between failures (MTBF) is 1 million lines.

The pin feed system can accept fanfold forms from 4.5 inches (11.5 cm) to 9.5 inches (24 cm) wide. The unit features top of form control and up to 10 vertical tab settings. Form length is software programmable in one-line increments.

The unit weighs 22 pounds and measures 7.3 by 17.7 by 14.8 inches (18 by 45 by 37 cm). The Centronics-compatible parallel interface version is priced at $750 and the serial (RS-232) version is priced at $835. The MT-80G, with an IEEE-488 interface, is also available. Contact Microtek Inc, 7844 Convoy Ct, San Diego CA 92111.

Circle 603 on inquiry card.

Versatile Printer from Malibu Design Group



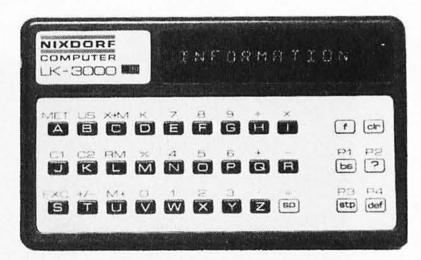
The Model 165 printer can be operated as a high-speed dot matrix printer at 165 characters per second (cps); a reduced speed, letter-quality dot matrix printer at 90 cps; or a full graphics matrix printer. The 165 printer can do computer portraits, custom character sets such as Japanese, music symbols, high-density characters for word processing, and more.

Underlining, expanded characters, programmable horizontal and vertical tabs, selectable left margin, user adjustable platen and a feature that shuts off the fan when the printer is idle (which reduces noise and power consumption) are some of the features of this printer.

Price for the basic Model 165 is $2395 from Malibu Design Group Inc, 8900 Eton Ave, Suite G, Canoga Park CA 91304.

Circle 604 on inquiry card.

Pocket Computer for General-Purpose Use



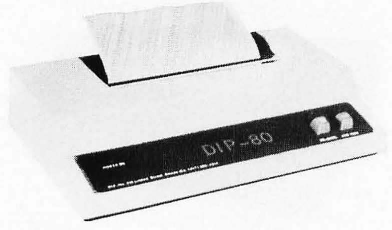
Using easily loaded electronic applications modules, the Nixdorf LK-3000 personal computer can be freely programmed to be used as a personal date book or telephone directory, or it can function as a data collection system capable of communication with other data processing systems. The unit also functions as a hand-held language dictionary to translate German, English, French, Greek, Italian, Spanish, Polish and Swedish words and idioms. The unit is produced by Nixdorf Computer Corp, 168 Middlesex Tpke, Burlington MA 01803, and is priced at $140.

Circle 605 on inquiry card.

What's New?

PERIPHERALS

Inexpensive and Compact Printer



The low-profile DIP-80 features 7 by 7 or 14 by 14 dot matrix printing, upper and lowercase character set, 100 character per second (cps) bidirectional printout, roll or fanfold paper, a full 96-character ASCII set, upper and lowercase printing at either 80 or 96 characters per line on 8.5 inch wide paper, and a 2-line buffer. Paper feed, at the rate of 1 line per second, is accomplished through a friction roller. Interface options include Centronics-compatible parallel, RS-232C serial or 20 mA current loop. The printer measures 15.75 by 9 by 3.5 inches (40 by 23 by 8.8 cm) and is available from DIP Inc, 210 Lincoln St, Boston MA 02111, for $625.

Circle 606 on inquiry card.

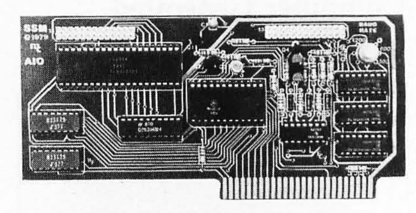
Telecommunications Facility for Transmitting and Receiving CP/M

The Byrom Software Telecommunications Access Method (BSTAM) allows transmission of program or data files between any two computers and is compatible with all 8080/Z80 systems using CP/M operating systems or a derivative, including Heath and TRS-80 adaptations. Transmissions are made over a normal voice-grade telephone line at 300 bits per second (bps) and over direct wire interconnections at 9600 bps. Error checking, cyclic redundancy check (CRC) error checking, protocol information, and group file transmission are featured but no data expansion is performed, resulting in fast transfers. BSTAM can precisely transfer data over poor circuits, with retry provisions and perfect reporting in the event of hard errors. The user interface allows a long sequence of files to be sent, with the file names automatically announced to the receiving computer. Sample drivers for 8250, 8251, 6850 and other Universal Asynchronous Receiver Transmitters (UARTs) are provided.

BSTAM comes on floppy disk for $150. Documentation is $5. Contact Lifeboat Associates, 2248 Broadway, New York NY 10024.

Circle 607 on inquiry card.

Apple Serial and Parallel Interface



The A10 interface allows maximum flexibility for interfacing an Apple II with peripherals such as printers, plotters, terminals, modems and other computers. The software-programmmble serial interface uses the RS-232 standard and includes three handshaking lines. A switch selects nine standard data transmission rates. On-board firmware provides a powerful driver routine that eliminates the need to write any software to utilize the interface. The A10's parallel interface features software programmable I/O ports with enough lines to handle two printers simultaneously with handshaking control.

The A10 comes with serial interface firmware, two cable assemblies and a manual with easy to follow application notes. It is priced at $175 assembled, and $135 in the kit form, from SSM (Solid State Music), 2116 Walsh Ave, Santa Clara CA 95050.

Circle 608 on inquiry card.

Single Chip Real-Time Signal Processor



Intel Corp has developed a single chip real-time analog input/output (I/O) microcomputer, the 2920 Signal Processor, and the SP20 hardware and software support package. The 2920 converts analog input signals to digital information, processes this information in its computer, and produces analog outputs in a real-time mode. The SP20 support package, a 2920 software simulator assembler and 2920 erasable-programmable read-only memory (EPROM) board, run on the Intellec Microcomputer Development System. The 2920 interfaces directly with analog signals using the on-chip circuitry and can handle multiple signals using I/O multiplexers, enabling thousands of complex analog systems to be formulated from one standard integrated circuit. The device can implement functions such as filters, limiters, oscillators, modulators and demodulators, nonlinear conversions, and perform logical operations all under program control.

The 2920 can be used in phase lock loops, complex filters, test and instrumentation circuits, speech processing, medical electronics, and many other applications. The 2920 device costs about $300 and the support package costs $3400. Contact Intel Corp, 3065 Bowers Ave, Santa Clara CA 95051.

Circle 609 on inquiry card.

What's New?

PUBLICATIONS

Bubble Memory Design Handbook



A 64-page catalog presenting the features, descriptions and functional characteristics of the 7110 1 M bit bubble memory and its support device family is now available from Intel Magnetics Inc. Included in the handbook are specifications, diagrams, and tables for the 7110 magnetic bubble memory, the 7220 controller, 7230 current pulse generator, 7242 dual formatter/sense amplifier, 7250 coil predriver, 7254 quad VMOS drive transistors, and IMB-100 development board.

Contact Intel Literature Dept, 3065 Bowers Ave, Santa Clara CA 95051, for free copies of the guide.

Circle 610 on inquiry card.

Quarterly Review of Software for TRS-80

80 Software Critique is a collection of reviews of TRS-80 cassette software. Program reviews are included only if they have been run several times; weak points and bugs in programs are documented. Program reviews include games, simulations, educational programs, music programs, and others. Business software is not included. Names and addresses of software vendors are provided and software prices are included. A one year (4 issues) subscription is $24 and the price of a single issue is $7. Write to *80 Software Critique*, POB 134 Waukegan IL 60085.

Circle 611 on inquiry card.

New Heathkit Catalog Available Free

A new 96-page catalog describing nearly 400 electronic kits designed for the hobbyist is available from Heath Co, Dept 350-880, Benton Harbor MI 49022. New products in this catalog include the H89 computer, a 3.5 digit auto ranging multimeter, a low-priced DC to 5 MHz single-trace oscilloscope, and more.

Circle 612 on inquiry card.

Wall Chart and Book on the Z80

The Working Programmer Press, 5080 Shady Ave, San Jose CA 95129, has the Z80 processor pins and elements on a wall-chart poster and work-sheet that measures 18 by 24 inches (46 by 60 cm). It retails for $7.95 by mail.

The drawings are from the book *The Z80, How It Works, A Programmers Perspective*, published by Microware Associates Inc, Scottsdale AZ. The book describes the working and programmable elements for the Z80. Sections on instruction cycles with detailed register interactions are included.

Circle 613 on inquiry card.

New Language for the 6502 User

XPLO is a simplified Pascal-type language available for 6502 systems with less than 32 K bytes of memory. It is a fast, structured compiler, so users can talk to their computers in their own language. Versions for 20 K Apple II, KIM, TIM, and SYM systems are available for under $70. For further information on XPLO and other languages, assemblers, and games, plus a free catalog, write to The 6502 Program Exchange, 2920 Moana, Reno NV 89509.

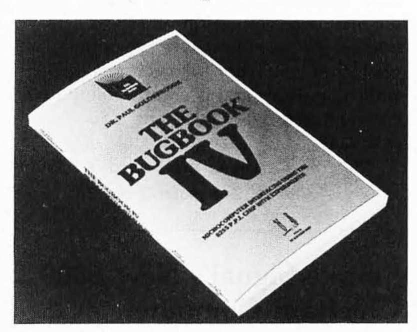
Circle 614 on inquiry card.

Educational Software Catalog for Personal Computers

A new mail order catalog devoted exclusively to educational software is being published by Queue, 5 Chapel Hill Dr, Fairfield CT 06432. The catalog will contain listings from numerous publishers. Software listings will be separated by educational level and field, and by computer. Listings for all popular personal computers will be included, and all software can be ordered directly from Queue.

Circle 615 on inquiry card.

Bugbook IV, Microcomputer Interfacing with the 8255 PPI Chip



This new book details microcomputer input/output (I/O) techniques and their implementation with the 8255 Programmable Peripheral Interface (PPI) integrated circuit. Techniques and experiments are presented in such a way that the principles can be applied to other PPI chips by students, scientists and engineers. All of the modes of operation are detailed, and a clear explanation of data transfer processes, flag sensing, bit testing, and similar topics are included. The price is $8.50. For more information, contact E and L Instruments Inc, 61 First St, Derby CT 06418.

Circle 616 on inquiry card.

Analog Dialogue



This publication includes application articles on very high-speed data acquisition, statistics methods using RMS to DC, checking converter linearity, a 300 kHz continuous 12-bit conversion system, and more. Product descriptions include voltage to current (V/I) converters for process control, a 14-bit sample/hold amplifier, CMOS switches, three power supplies, and several data converters. The booklet is available for free from Analog Devices, Rt 1 Industrial Park, POB 280, Norwood MA 02062.

Circle 617 on inquiry card.

Connecticut microComputer Catalog

This catalog presents the Data Acquisition Modules Systems (DAM), including the AIM 16 analog to digital (A/D) converter. The publication also includes program reviews and a list of dealers for the company's products. Contact Connecticut microComputer Inc, 150 Pocono Rd, Brookfield CT 06804.

Circle 618 on inquiry card.

What's New?

MISCELLANEOUS

Parallel Input/Output and Timer Board

A parallel input and output (I/O) board has been developed by Tecmar Inc, 23414 Greenlawn Ave, Cleveland OH 44122, for interprocessor communications. It has two 16-bit parallel input ports and two 16-bit parallel output ports, status word for polled operation, interrupts for vectored interrupt operation, and is individually maskable from software.

Tecmar also has a 16-bit timer with 8-bit prescaler, intervals up to 8.4 seconds with resolution of 128 microseconds, status byte for polled operation, interrupt for vectored interrupt operation, and is compatible with conventional S-100 8080 and Z80 systems.

The cost for the entire board is $350.

Circle 619 on inquiry card.

A Single Board Computer System

The VP Single Board Computer System provides the functions needed for business, process control or software development systems. No other boards of any type are required. Incorporating on-board voltage regulators, it will even operate from a 12 V battery. The multiple serial and parallel input and output (I/O) ports allow the VP to interface with transducers, modems, couplers, terminals, printers, plotters, digitizers, temperature, pressure, voltage monitors and many other devices with an electrical output. The typical configuration includes a Z80 processor, Centronics printer port, 8-bit parallel input port, RS-232C serial port, disk controller for eight drives, and 32 K bytes of programmable memory. The software library includes operating systems, BASIC, CBASIC, FORTRAN, COBOL, and business accounting, payroll, and word processing packages. The board is available from Data World Inc, 7541 Ravensridge Dr, St Louis MO 63119, for $900.

Circle 620 on inquiry card.

Computer Games Telephone Network

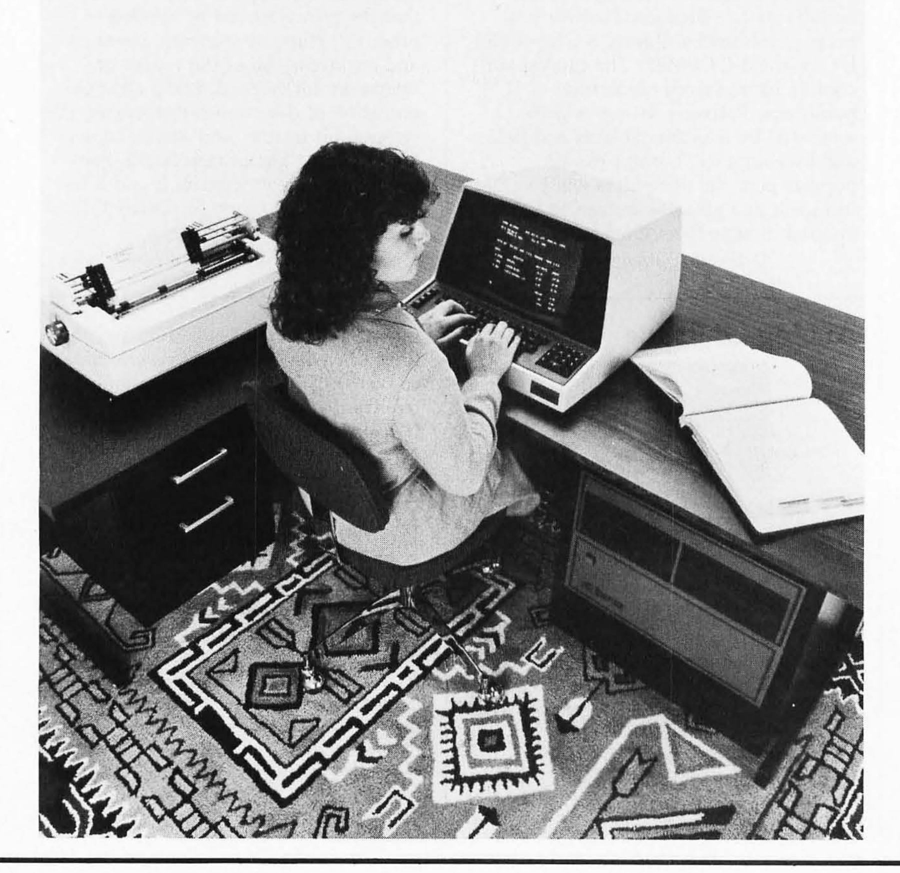
GameMaster is a computer gaming information network that is available for PET, Apple II, TRS-80, and any other personal computer that is outfitted with a modem. The system offers games, information, educational programs and other items of interest for computer users in the Midwest. For more information, contact GameMaster, 205 W Wacker Dr, Suite 1517, Chicago IL 60606.

Circle 621 on inquiry card.

Smoke Signal's New 6809 Chieftain Computer

Smoke Signal Broadcasting has developed a new integrated computer system utilizing the Motorola 6809 processor, and configured around the new Chieftain microcomputer with programmable read-only memory (PROM) or erasable-programmable read-only memory (EPROM) storage, and a minimum of 32 K bytes of programmable memory.

The system also includes expansion capability to at least 256 K bytes — and perhaps up to 1 megabyte — requiring larger memory cards than the current 16 K byte board. In addition, the new motherboard will handle as many as sixteen serial or parallel ports in its 30-pin input/output (I/O) section. Nearly unlimited I/O capability is possible if the user wishes to use any of the 50-pin positions.



Smoke Signal has also developed a new disk controller allowing either single- or double-density recording techniques to be employed. Along with the ability to handle double-sided disks, users can store up to 1 megabyte on each 8-inch floppy disk (320 K bytes on a 5-inch floppy disk). Current users of any SS-50 bus disk system compatible with the Smoke Signal system can purchase the controller board separately or as part of the new Chieftain.

The new controller allows instant access and immediate response to an interruption request at any time during disk operation or other multiuser applications. The unit can be expanded for multiuser operation.

The Smoke Signal disk operating system has been converted to run on the 6809, as well as the text editor and text word processor. All higher-level languages are available for the 6809 including UCSD Pascal.

A hard disk capability on the order of 15 megabytes of fixed storage and 15 megabytes of removable storage is available, expandable to 80 megabytes of fixed storage.

For more information, contact Smoke Signal Broadcasting, 31336 Via Colinas, Westlake Village CA 91361, or call (213) 889-9340.

Circle 622 on inquiry card.

What's New?

MISCELLANEOUS

Fiber Optic Evaluation Kit for Systems Engineers



Motorola has introduced a fiber optic evaluation kit, developed to give designers experience with the latest fiber optic components. The kit is called The Link, and refers to the optical link between the transmitter and receiver of any system with all of the optical portions needed. The kit includes an MFOE103FB fiber optic infrared light-emitting diode (LED) source, an MFOD402FB integrated detector/preamplifer, a 1 meter length of fiber optic glass cable with matching AMP connectors, design considerations, applications and circuit ideas.

Price for the kit is $99. Additional ferrule semiconductors and components are available. Contact Motorola, POB 20912, Phoenix AZ 85036.

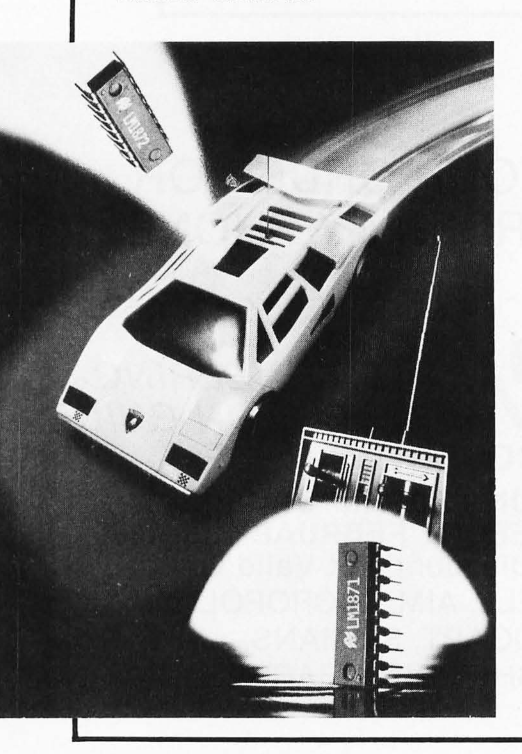
Circle 629 on inquiry card.

The BASIC Programmer's Toolkit

The Toolkit is a collection of machine language firmware aids designed to enhance the writing, debugging and polishing of BASIC programs for the PET. This 2 K byte read-only memory chip offers additional read-only memory storage, avoiding any need to load tapes or give up valuable programmable storage. The Toolkit contains 10 powerful commands to help programmers with their PET. The board attaches to the memory expansion port of any 8 K byte PET. The Toolkit costs $79.95 and the version for the 16 K or 32 K byte PET retails for $49.95. For more information, contact Palo Alto ICs, 430 Sherman Ave, Palo Alto CA 94306.

Circle 630 on inquiry card.

Low-Cost Transmitter/Receiver Integrated Circuit Pair for Radio Control



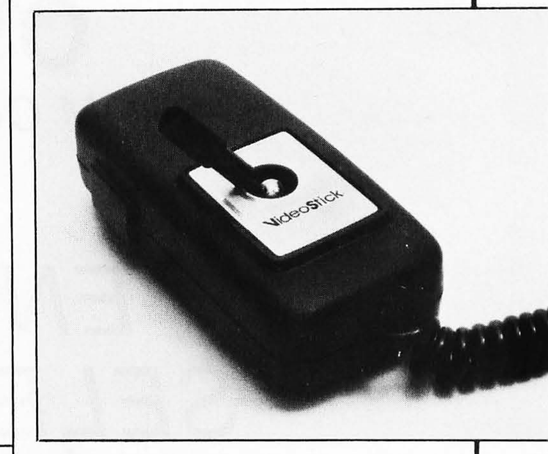
National Semiconductor Corp has developed a low-cost transmitter/receiver pair of integrated circuits that allow for the design of lightweight and compact remote control systems. The LM1871 and 1872 make use of an unusual pulse code modulation technique that allows the chip set to handle analog and digital control signal information. The chip set is adaptable for use in toys, such as model cars, airplanes and trucks with simple on/off digital control to sophisticated units with several channels of proportional analog control.

The LM1871 and 1872 feature two digital and two analog channels for control, operation in the 27 MHz and 49 MHz unlicensed bands or in the 72 MHz licensed band, 50 meter outdoor control range, and an internal voltage regulator which keeps radiated power constant even if the supply voltage changes. The chips have built-in flip-flops which eliminate the need for bulky timing components.

The devices come in 18-pin dual inline packages and operate on 9 V or less. They are priced at approximately $12 for the set. For more information, contact National Semiconductor Corp, 2900 Semiconductor Dr, Santa Clara CA 95051.

Circle 631 on inquiry card.

Joystick for Apple II

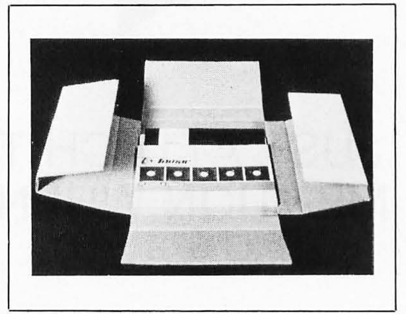


ISC Inc, 2224-C Old Middlefield Way, Mountain View CA 94043, has introduced the Model VS20/APL Videostick X/Y controller for the Apple II. The unit features a large push (firing) button and a linear joystick designed specifically for applications such as plotting graphics or playing games. The controller plugs directly into the Apple II and can be hand-held or table positioned.

The Videostick is priced at $39.95, and is available from Computer Plus Inc, 1324 S Mary, Sunnyvale CA 94087.

Circle 632 on inquiry card.

Floppy Disk Mailer



Inmac, 2465 Augustine Dr, POB 4780, Santa Clara CA 95051, has designed a floppy disk mailer that protects up to five standard floppy disks or five 5-inch floppy disks against bending, curling or cupping in transit. The disks are placed in the center of the new Inmac mailer, then the mailer is folded according to the instructions printed on the mailer itself, assuring safety in mailing. Consisting of 10 mailers, a package costs $10. When purchased simultaneously, three or more packages cost $8.50 per package.

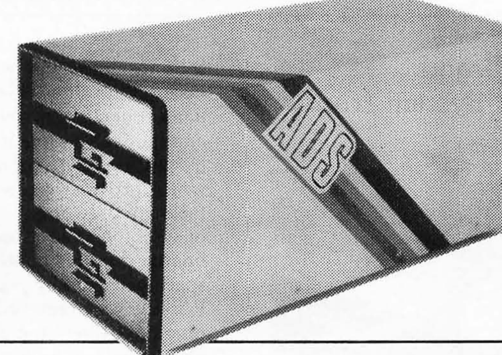
Circle 633 on inquiry card.

MATCHMAKER TECHNOLOGY

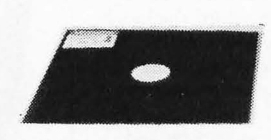
TURNKEY DISK SUBSYSTEMS

DISK IS IN!!!

✔ SORCERER
✔ TRS-80
✔ APPLE
✔ HPIB
✔ PET



For those who wish to avoid the aggravation, fussing, irritation, annoyance etc., of assembling your own subsystem, plug in and GO!!!



APPLE

FEATURES:
- 2 8″ Floppy DISK DRIVES (Single Sided)
- Color Coordinated Cabinet with Power Supply
- Expanded version of APPLE-DOS
- Single Density Disk Controller
- Full Cabling, Connectors + Documentation
- Assembled and Tested
- Plug In and GO!!! **$1695.00**

OPTIONS:
- 2 8″ Double Sided Drives (In place of Single Sided) **$2395.00**
- 16K Internal Memory Expansion Kit **69.00**

PET

Prices and specifications same as for APPLE except PET Operates via PET-DOS

TRS-80

Prices and specifications same as for SORCERER with following exceptions:
- Expansion Interface necessary
- Space for up to 48K plug-in dynamic memory on Controller Card
- Software package as above **$ 995.00**

SORCERER

FEATURES:
- 2 8″ Single Sided Floppy Disk Drives
- Single and/or Double Density
- Color Coordinated Cabinet with Power Supply
- Full RS-232 Interface
- OS-1 Disk Operating System (Fully CP/M compatible) CP/M is a registered trademark of Digital Research
- Full Cabling, Connectors + Documentation
- Assembled and Tested
- One S-100 Slot available for Memory Expansion
- Plug In and GO!!! **$2195.00**

OPTIONS:
- 2 8″ Double Sided Drives (In place of Single Sided) **$2845.00**
- 32K Dynamic RAM Memory Board, Assembled and Tested **$ 299.00**
- 16K Dynamic RAM Internal Memory Expansion Kit **$ 69.00**
- Deluxe Business Software package includes:
  C BASIC
  WORD PROCESSING SOFTWARE
  INTERACTIVE "Big 4":
  General Ledger, Accts. Payable, Accts. Rec. and Payroll **$ 695.00**
- 10 MBY Removeable Hard Disk — Call for Details

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Electrolabs

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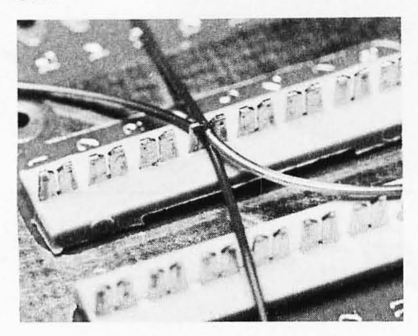
Worldwide:
TLX: 345567 Electrolabs PLA

Circle 207 on inquiry card.

What's New?

MISCELLANEOUS

Scotchflex Brand Breadboard System from 3M



3M has developed a breadboard system that eliminates stripping, soldering and crimping of wires. Connections are made with continuous, 30 AWG solid insulated wire which is easily inserted into the "U"-contact with a hand-tool supplied by 3M, saving time and labor. Multiple bussing is simplified by putting 2 wires into each contact which provides 4 connections. The contacts are only about one-third the height of wrap posts so prototype circuit boards can be mounted in the same space occupied by production boards. Wires can be removed without unwrapping or cutting, and dual sockets and plug strips can be removed with an inexpensive hand-tool, simplifying reuse of the board and components.

Kits with 8 contact solder strips, plug strips, 16 position dual sockets and Scotchflex "U"-contacts cost $97.50. Separate components are also available. Contact 3M Co, POB 33600, St Paul MN 55133, Dept EP9-9.

Circle 638 on inquiry card.

Heathkit H8 Extender Board Kit



The H8 Extender Board allows Heathkit owners to troubleshoot their machine easily because each board is up above the computer for access to all circuits and components. Jumper links in power lines make power measurement simple. The links can be replaced with fine copper wire, which protects the traces or the motherboard from damage due to excessive current during testing.

The kit features a double-sided printed circuit board, with plated through holes, and a Molex, 25-pin edge connector, with formed leads.

The kit is available from Mullen Computer Products inc, POB 6214, Hayward CA 94545, for $39.

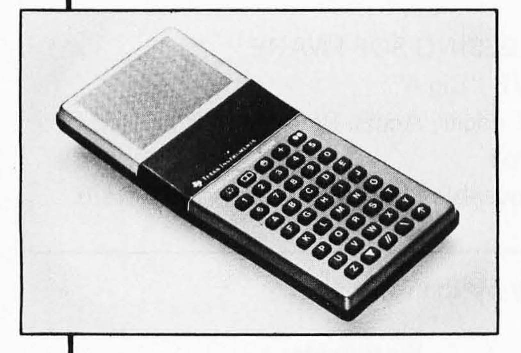
Circle 640 on inquiry card.

Microcomputer Users Provided Access to Commodity Futures Data Base

A commodity futures data base, used by professionals in the field, is being made available to personal computer owners. The MJK data base provides daily information on 38 major commodities including interest rate futures and foreign currencies, as well as agricultural commodities with cash and price information on many. The data becomes available at 2:15 PM (PST) each trading day. In addition to providing daily price, volume and open interest data, MJK makes available a series of programs for calculating moving averages, spread charts, bar graphs, etc. POISE is a special program for testing trading systems in the history of the data base.

A minimum of $25 per month is charged after a subscriber set-up fee of $25. Additional charges for the service are $16 per hour for connect time and 14¢ a second for processor usage. Included is the cost of TYMNET, providing telephone connection at local message-unit rates from most US population centers. For further information, contact Krause and Co, Central Tower Building, San Francisco CA 94103. Circle 639 on inquiry card.

Talking Language Translator Is Introduced by Texas Instruments



A talking Language Translator, utilizing speech synthesis and offering solid state electronic modules for English, French, German and Spanish, has been introduced by Texas Instruments Inc, POB 53, Lubbock TX 79408. Designed for world travelers as an aid in communicating in a foreign country and for language students in learning to pronounce a foreign language, the handheld device is programmed with a vocabulary of words and phrases selected for everyday use, and can be used as a basic vocabulary for learning a language.

The Language Translator has the ability to form thousands of spoken phrases by linking together its spoken vocabulary words. Each module contains about 1000 words of which half will be spoken and displayed, while half will be displayed only. Components include a speech synthesizer integrated circuit, a controller, and four read-only memories. An earplug is provided for quiet use.

There are five basic functions for users:

- Common phrases - allows user to key-in a numerical code to access one of 25 preprogrammed phrases.
- Partial phrases - users may form thousands of their own phrases by linking preprogrammed partial phrases with words from the word memory.
- Translate mode - translates 1000 words from input language to output language.
- Memory learn mode - drills user on pronunciation and translation of user-selected words.
- In the learn mode - a programmed drill assists the user to learn.

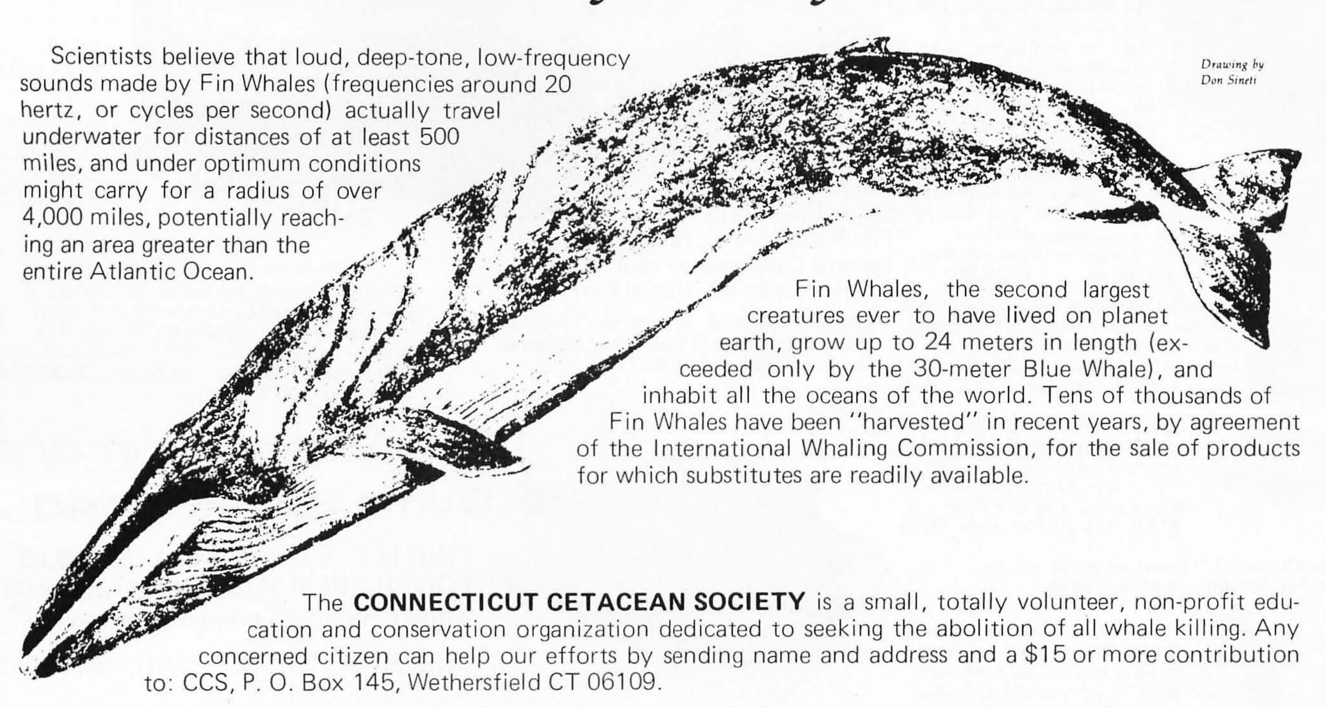
The Language Translator is priced at approximately $250.

English, Spanish, French and German modules are available. Japanese and Chinese will be ready in the first quarter of 1980. The approximate price of each is $50.

Circle 641 on inquiry card.

SAVE THE WHALE

The Fin Whale is the world's greatest long-distance communicator.



Drawing by Don Sineti

Scientists believe that loud, deep-tone, low-frequency sounds made by Fin Whales (frequencies around 20 hertz, or cycles per second) actually travel underwater for distances of at least 500 miles, and under optimum conditions might carry for a radius of over 4,000 miles, potentially reaching an area greater than the entire Atlantic Ocean.

Fin Whales, the second largest creatures ever to have lived on planet earth, grow up to 24 meters in length (exceeded only by the 30-meter Blue Whale), and inhabit all the oceans of the world. Tens of thousands of Fin Whales have been "harvested" in recent years, by agreement of the International Whaling Commission, for the sale of products for which substitutes are readily available.

The **CONNECTICUT CETACEAN SOCIETY** is a small, totally volunteer, non-profit education and conservation organization dedicated to seeking the abolition of all whale killing. Any concerned citizen can help our efforts by sending name and address and a $15 or more contribution to: CCS, P. O. Box 145, Wethersfield CT 06109.

UP TO 25% OFF

YOUR OWN TRS-80 SYSTEM AT TREMENDOUS SAVINGS

① TRS-80 Complete System

Includes: CPU/Keyboard, Power Supply, Video Monitor, Cassette Recorder, Manual, and Game Cassette.

② Line Printer
③ Mini Disk System
④ C-10 Cassettes
⑤ Verbatim Diskettes



DISK DRIVES IN STOCK!

ITEM		REG. PRICE	OUR PRICE
Level II—4k		$619.00	$575.70
Level II—16k		$849.00	$789.60
Expansion Interface		$299.00	$278.10
Mini Disk Drive		$ 495.00	$ 385.00
Centronics 730 Printer		$ 995.00	$ 850.00
Centronics 101 Printer		$1595.00	$1400.00
Anadex DP-8000 Printer		$ 895.00	$ 995.00
Memory Kit (16K) FREE INSTALLATION		$ 149.00	$ 98.00
Verbatim Diskettes ea.		$ 5.95	$ 4.95
	3	$ 17.89	$ 12.00
	10	$ 59.00	$ 37.00
C-10 Cassettes	5	$ 4.95	$ 4.50
	25	$ 24.75	$ 18.75
Paper (9½" x 11" fanfold. 3500 sheets)		$ 35.00	$ 29.95

SALE

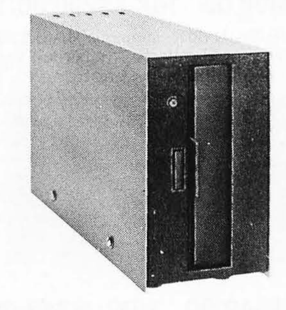
Centronics 779 — $995.00
Same as Line Printer I (Tractor)

TRS—80 MODEL II — $3626.00
- **64K RAM**
- **½ MEG DISK**

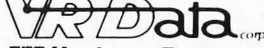
ADDITIONAL DISK DRIVE (1ST) $1069.50
ADDITIONAL DISK DRIVE (2ND + 3RD) $ 558.00

MINI DISK DRIVES NOW $385

Over $100 less than Radio Shack's!



There are new developments every day—write or call for the latest information.



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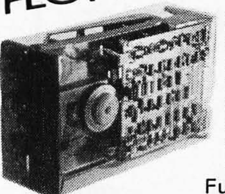


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1-(800) 345-8102 *Orders only!

FOREIGN and DOMESTIC DISTRIBUTORSHIPS AVAILABLE . . .

Circle 206 on inquiry card.

FLOPPY SYSTEMS



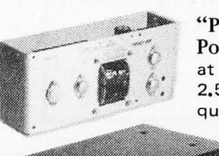
8" Siemens FDD120-8D All Siemens options included in this drive may be configured hard or soft and single or double density. We find this to be an extremely reliable drive. $430.00
Fully Shugart compatible.

5¼" BASF Magical Miniature Mini drive only 2/3 the size of others is reliable and durable and quickly gaining in popularity with our customers. Single or dual density fast access times $259.00

Tarbell Controller may be reconfigured to control 5¼" drives and includes short cable for one drive. KIT $179.00, ASM $265, but only $219 with purch. of 2 drives.

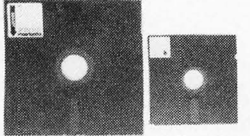
Cable Kits For 8" Drives with 10' 50 cond. cable and connectors. Also power cable and connectors. Flat cable assem if you wish. For one drive 27.50, two 33.95, three 38.95

Cable Kits for 5¼" Drives as above, but 34 cond. For one drive **24.95**, two **29.95.**



"Power One" Model CP206 Power Supply adequate for at least two drives. 2.8A/24V 2.5A/5V, 0.5A/-5V beautiful quality. $99.00

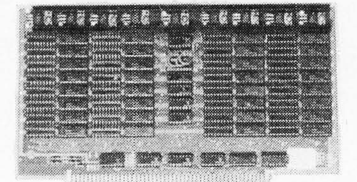
CABINETS for FDD120 and 801R drives, or CP206 supply. Matte finish in mar resistant black epoxy paint and stacking design 29.95



DISKETTES (3M, MRX, BASF, Georgia Magnetics, & Victor Borge)
8" $39.95/10
5¼" $29.95/10

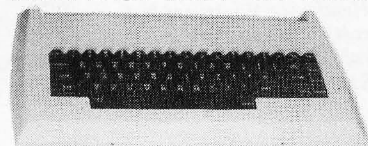
32K - $490.00 16K - $290.00

NEW!! — CHRISLIN 64K Dynamic RAM $750.00
(Showing Amazing Similarity to Tarbell's unit)
(16K Shown in photo)

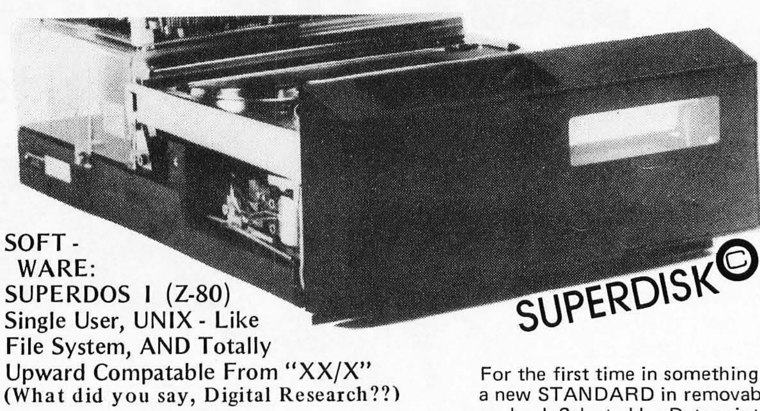


32K - $549.00 16K - $349.00

"BACK TO SCHOOL" KEYBOARD SPECIAL



CHERRY "PRO" Keyboard $119.00
Streamlined Custom Enclosure $34.95
BOTH ONLY $124.95 !!!!!!!!



SOFT - WARE:
SUPERDOS I (Z-80)
Single User, UNIX - Like File System, AND Totally Upward Compatable From "XX/X"
(What did you say, Digital Research??)

PS: SUPERDOS -I runs on the TRS-80, and can transform it from a toy computer to a real business machine !!!

10MBy DRIVE $3300

S - 100 DMA CONTROL

POWER UNIT $395.00

For the first time in something like 10 years, a new STANDARD in removable media has evolved. Selected by Datapoint, and others who have not yet announced, this drive is beautifully simple and easy, if not trivial to maintain. 920kBy/sec. transfer rate, 3600 RPM 39 lbs and only 125 Watts.

Daisy Wheel Printers

Qume Sprint 3\45

PRINTER (factory warr.) $1199.00
POWER SUPPLY (Boschert) $349.00
(shown mounted on rear of printer)

COMBINATION SPECIAL $1699.00

Electrolabs

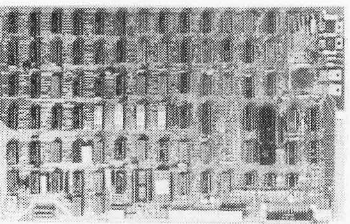
POB 6721, Stanford, CA 94305
415-321-5601 800-227-8266
Telex: 345567 (Electrolab Pla)
Visa MC Am. Exp.

DATA DISPLAY MONITORS

Used 12" Sylvania monitors. Composite Video, 15 MHz, 120VAC. Rebuilt with NEW P39 anti-glare tube $119.00
New P4, 109.00, used P4 79.00.
U-fix model, 10/$300.00



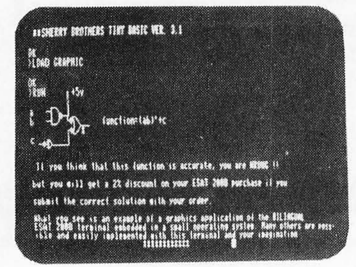
"OEM STYLE" as above, will fit any case. (Both versions serviced by qualified tech). Identical to above but subtract $12.00



ESAT 200B

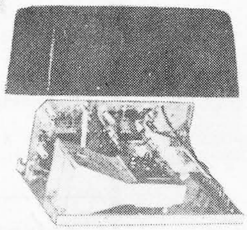
BI-LINGUAL 80x24 COMMUNICATING TERMINAL

Scrolling, full cursor, bell, 8x8 matrix, 110 - 19,200 baud, Dual Font Applications. Arabic & Hebrew, Multilingual Data Entry Forms Drawing, Music, & Switchyards. $349.00



New!

Doppler Motion Sensor Intrusion Detector



Extremely effective microwave motion detector for detecting unwanted visitors. Ignores mice and other non-larcenous creatures. Operates on 12VDC or from small transformer supplied. Output is relay closure for alarm control interface, or to switch on lights annunciators. Will operate THROUGH door of closet or thin wall. Best application seems to be to turn on outside lights to help invited guests, and to intimidate unwanted ones. $159.00
Water Repellent Cover $24.95

SOCKET SPECIAL

BURNDY
"Won't Let Go"
Low Profile
Solder Tail
1 CENT/ Pin !! (0.75/1000's)
8 14 16 18 20 22 24 28 40

Circle 207 on inquiry card.

CP/M* Source Code -- FREE! *when you purchase* **"OS-1"**

Electrolabs' new operating system for the Z-80 designed to have exactly the appearance of UNIX, including virtual I/O, "set TTY", a tree and a shell, filters and pipes PLUS total compatability with CP/M software!**

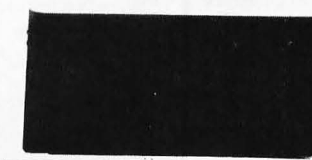
OS-1© FEATURES

(Because OS-1 is truly a comprehensive "OS", and not merely a file handling "DOS", we have changed the name from "Superdos" to "OS-1")

VIRTUAL I/O - copy with a single command between floppy and hard disk, or from TTY to printer to tape to disk... etc., etc. No messy I/O routines to write, & no awkward transfers.
SECURITY - 9 modes of file protection, user and login protection.
MULTI-USER - up to 256 passwords. (non-simultaneous users)
16MBy FILE SIZE - but no limit to no. of directories per device, thus allowing EASY implementation of gigantic storage devices.
"SET TTY" - for printer or crt: tabs, page width, buffer, cursor, UC/LC, fonts, formfeed, arbitrary control characters etc., etc.
"LOGIN" - automatically executes user selected programs and "set TTY".
OCCUPIES 12KBy - only 50% larger than CP/M, but 500% more features.
CP/M & CDOS COMPATABLE - your library is guaranteed to run!

*(*Naturally*, we are not giving away the version of CP/M written by Digital Research, Please pardon our pun, but they might object. What we ARE giving you is a greatly enhanced version of CP/M which resides on OS-1, and allows the user of OS-1 to run any and all of his programs, packages or system utilities which are already running on CP/M. We give you the source code at no charge so that you may modify any part of the CP/M to suit your own system requirements. At no charge, you also receive the enhancement allowing 4MBy files instead of 256K.)

OS-1 (with debugger, linker and screen oriented editor	**$199.00**
Update service, per year	**29.00**
Symbolic Debugger	**150.00**
MACRO-Assembler (Creates relocatable code)	**150.00**
"C" Compiler	**660.00**
FORTRAN Compiler	**100.00**
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PAPER TIGER

IDS MODEL 440

- 8 Software Selectable Character Sizes
- Parallel & Serial Interface
- 98 ASCII Character set, upper & Lower case
- Forms length control
- Tractor Feed $995.00

Graphics option with 2K CRT screen buffer add $199.00

DYNAMIC DEVICES MODEM



- Acoustically coupled modem assembly set
- Asynchrous 0-300 Baud
- Switchable originate or answer modes
- Operates full or half duplex mode
- 15 minute assembly $149.95

NEW YEAR'S IC SPECTACULAR

(While Supply Lasts)

MEMORY & EPROM

2114-	$ 3.00
2114-2	6.99
Pd411	2.50
2107 (pull outs)	2.00
7001 (pull outs)	2.00
4116 (set of 8, 16K)	69.00
5204	4.95
2708	8.95
2516	35.00
2716	35.00
TMS2716	19.00
2732	95.00

CPU

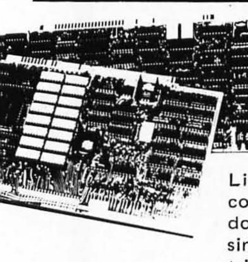
1802CD	$19.95
6502	6.25
Z-80	9.95
Z-80A	12.95
8080A	8.99
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8741	79.00

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1771	$26.95
1791	37.95
Pd372	39.00

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Telex: 345567 (Electrolab Pla)



Graphics

High Resolution 480 x 512
for B&W and Color Imaging and Graphics

Light pen, A-D, D-A, TV synchro (needs no time base correction or adjustment with anything between random interface & NTSC commercial standard). T.V. single frame grabber ("snapshot"). Up to 1 Byte of attributions per pixel.

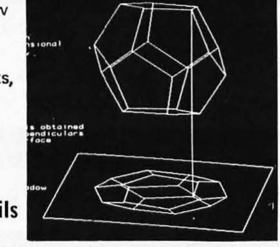
LSI-100 & S-100 applied to:

Graphic Presentation — such as computer generated animation & other graphic displays up to 256 colors & up to 256 b&w gray scales. **Image Analysis** — using built-in FRAME GRABBER, for medical image enhancement, contour analysis, & pattern recognition. **Commercial TV Tilting & Advertising** — using synchronization capability. **Interactive graphics** — using light pen accessory.

BASIC CONFIGURATION —
LSI-11 $1995. S-100 $1265.
For TRS-80/Exidy Add $595.00
Includes: Data Board - 32K (480 x 512 x 1 pixel) D-A 16 level video generator. Video Synchronization Circuitry. Address Control & Timing Board.

FEATURES — High speed. DMA or 2KBy window memory mapped interface. Full NTSC commercial color capability. Low power consumption. Excellent Software

Options — Accessories — Software
Options include: light pen, auxilliary outputs, text mode, memory and much more. Accessories include: b&w and color cameras and monitors. Software: "Plot" 2D or 3D, "Tilting", "Contour", "Image Enhancement", "Vector Curve Generation".



Call for price and details

*CPM and **UNIX
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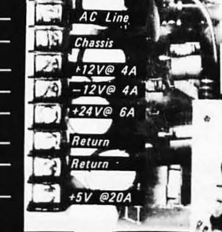
Electrolab's System Switcher Model SP04



Tames *RAW POWER* for the LSI-11/23 ★ And Hard Disks

FEATURES:
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Brown-Out Proof
Line Frequency Indifferent
Very Low EMI
U.L. Approved
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Open Frame Design
Short Circuit and OV Protection
20,000 Hour MTBF (MIL 217B)
Adaptable to Un-Interruptable Power applications. and
Low Cost!! (just look at DEC's price)





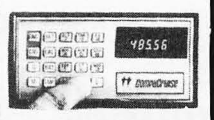
ElectroLabs



COMPUCRUISE

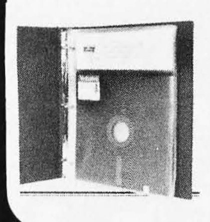
Put a computer in your car, which gives you the most effective and functional cruise control ever designed, plus complete trip computing, fuel management systems, and a remarkable accurate quartz crystal time system.

So simple a child can operate, the new CompuCruise combines latest computer technology with state-of-the-art reliability in a package which will not likely be available on new cars for years to come • Cruise Control • Time, E.T., Lap Timer, Alarm • Time, Distance, Fuel to Arrival • Time, Distance, Fuel to Empty • Time, Distance and Fuel on Trip • Current or Average MPG, GPH • Fuel Used, Distance since Fillup • Current and Average-Vehicle Speed • Inside, Outside or Coolant Temperature • Battery Voltage • English or Metric Display. $169.95, without cruise control $129.95.



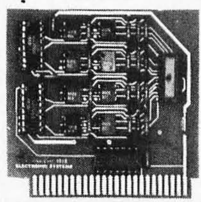
FLOPPY DISK STORAGE BINDER

This black vinyl three-ring binder comes with ten transparent plastic sleeves which accommodate either twenty, five-inch or ten, eight-inch floppy disks. The plastic sleeves may be ordered separately and added as needed. A contents file is included with each sleeve for easy identification and organizing. Binder & 10 holders $14.95 Part No. B800; Extra holders 95¢ each. Part No. 800



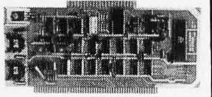
OPTO-ISOLATED PARALLEL INPUT BOARD FOR APPLE II

There are 8 inputs that can be driven from TTL logic or any 5 volt source. The circuit board can be plugged into any of the 8 sockets of your Apple II. It has a 16 pin socket for standard dip ribbon cable connection.
Board only $15.00. Part No. 120, with parts $69.95. Part No. 120A.



TIDMA

• Tape Interface Direct Memory Access • Record and play programs without bootstrap loader (no prom) has FSK encoder/decoder for direct connections to low cost recorder at 1200 baud rate, and direct connections for inputs and outputs to a digital recorder at any baud rate • S-100 bus compatible • Board only $35.00 Part No. 112, with parts $110 Part No. 112A

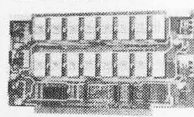


SYSTEM MONITOR

8080, 8085, or Z-80 System monitor for use with the TIDMA board. There is no need for the front panel. Complete with documentation $12.95.

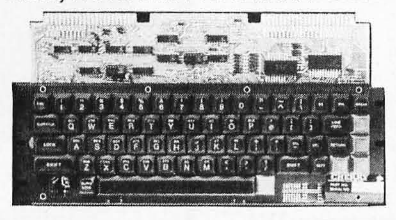
16K EPROM

Uses 2708 EPROMS, memory speed selection provided, addressable anywhere in 65K of memory, can be shadowed in 4K increments. Board only $24.95 part no. 7902, with parts less EPROMs $49.95 part no. 7902A.



ASCII KEYBOARD

TTL & DTL compatible • Full 67 key array • Full 128 character ASCII output • Positive logic with outputs resting low • Data Strobe • Five user-definable spare keys • Standard 22 pin dual card edge connector • Requires +5VDC, 325 mA. Assembled & Tested. Cherry Pro Part No. P70-05AB. $119.95.



ASCII KEYBOARD

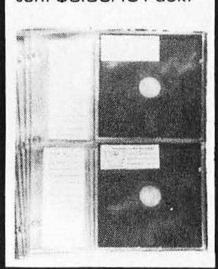
53 Keys popular ASR-33 format • Rugged G-10 P.C. Board • Tri-mode MOS encoding • Two-Key Rollover • MOS/DTL/TTL Compatible • Upper Case lockout • Data and Strobe inversion option • Three User Definable Keys • Low contact bounce • Selectable Parity • Custom Keycaps • George Risk Model 753. Requires +5, -12 volts. $59.95 Kit.

ASCII TO CORRESPONDENCE CODE CONVERTER

This bidirectional board is a direct replacement for the board inside the Trendata 1000 terminal. The on board connector provides RS-232 serial in and out. Sold only as an assembled and tested unit for $229.95. Part No. TA 1000C

DISK JACKET™

Made from heavy duty .0095 matte plastic with reinforced grommets. The mini-diskette version holds two 5-1/4 inch diskettes and will fit any standard three ring binder. The pockets to the left of the diskette can be used for listing the contents of the disk. Please order only in multitudes of ten. $9.95/10 Pack.



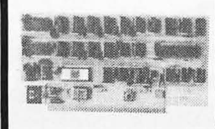
ATARI 800

Computer with 8K $995.00, disk drive $549.00, printer $599.99



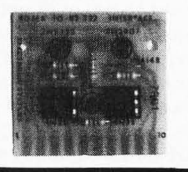
VIDEO TERMINAL

16 lines, 64 columns • Upper and lower case • 5x7 dot matrix • Serial RS-232 in and out with TTL parallel keyboard input • On board baud rate generator 75, 110, 150, 300, 600, & 1200 jumper selectable • Memory 1024 characters (7-21L02) • Video processor chip SFF96364 by Neculonic • Control characters (CR, LF, →, ←, ↑, ↓, non destructive cursor, CS, home, CL • White characters on black background or vice-versa • With the addition of a keyboard, video monitor or TV set with TV interface (part no. 107A) and power supply this is a complete stand alone terminal • also S-100 compatible • requires +16, & −16 VDC at 100mA, and 8VDC at 1A. Part No. 1000A $199.95 kit.



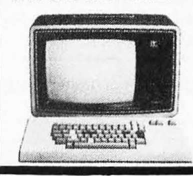
RS-232/20mA INTERFACE

This board has two passive, opto-isolated circuits. One converts RS-232 to 20mA, the other converts 20mA to RS-232. All connections go to a 10 pin edge connector. Requires +12 and -12 volts. Board only $9.95, part no. 7901, with parts $14.95 Part No. 7901A.



COMPUCOLOR II

Model 3, 8K $13 95,
Model 4, 16K $15 95,
Model 5, 32K $18 95.
Prices include color monitor, computer, and one disk drive.



PET COMPUTER

With 32K & monitor - $1195. Dual Disk Drive - $1195.

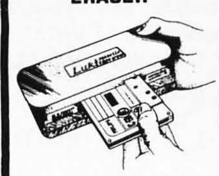


apple II or APPLE II PLUS

16K - $995, 32K - $1059, 48K - $1123. Disk & cont. $589



CASSETTE TAPE ERASER



REMOVES RECORDINGS IN ONE SECOND! The process eliminates static positive / negative ions and maintains original tone quality with minimal tape hiss • To improve tone quality • To reduce hissing • For quick and easy to erase • No battery or liquid required • Powerful and effective action • Unconditional 2 year guarantee. ERASER-8 $19.95.

16K RAMS

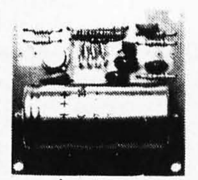
For the Apple, TRS-80 or Pet $8 each Part No. 4116/2117.

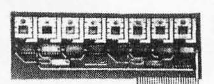
APPLE II HOBBY/ PROTOTYPING CARD

$14.95 Part No. 7907

T.V. INTERFACE

• Converts video to AM modulated RF, Channels 2 or 3. So powerful almost no tuning is required. On board regulated power supply makes this extremely stable. Rated very highly in Doctor Dobbs' Journal. Recommended by Apple • Power required is 12 volts AC C.T., or +5 volts DC • Board only $7.60 part No. 107, with parts $13.50 Part No. 107A





PARALLEL TRIAC OUTPUT BOARD FOR APPLE II

This board has 8 triacs capable of switching 110 volt 6 amp loads (660 watts per channel) or a total of 5280 watts. Board only $15.00 Part No. 210, with parts $119.95 Part No. 210A.

To Order: Mention part no. description, and price. In USA shipping paid by us for orders accompanied by check or money order. We accept C.O.D. orders in the U.S. only, or a VISA or Master Charge no., expiration date, signature, phone no., shipping charges will be added. CA residents add 6.5% for tax. Outside USA add 10% for air mail postage and handling. Payment must be in U.S. dollars. Dealer inquiries invited. 24 hour order line (408) 448-0800

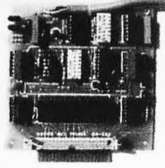


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TRS-80 E.S. SERIAL I/O

• Can input into basic • Can use LLIST and LPRINT to output, or output continuously • RS-232 compatible • Can be used with or without the expansion bus • On board switch selectable baud rates of 110, 150, 300, 600, 1200, 2400, parity or no parity odd or even, 5 to 8 data bits, and 1 or 2 stop bits. D.T.R. line • Requires +5, -12 VDC • Board only $19.95 Part No. 8010, with parts $59.95 Part No. 8010A, assembled $79.95 Part No. 8010 C. No connectors provided, see below.



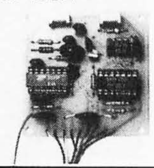
EIA/RS-232 connector Part No. DB25P $6.00, with 9', 8 conductor cable $10.95 Part No. DB25P9.



3' ribbon cable with attached connectors to fit TRS-80 and our serial board $19.95 Part No. 3CAB40.

MODEM

• Type 103 • Full or half duplex • Works up to 300 baud • Originate or Answer • No coils, only low cost components • TTL input and output-serial • Connect 8 Ω speaker and crystal mic. directly to board • Uses XR FSK demodulator • Requires +5 volts • Board only $7.60 Part No. 109, with parts $27.50 Part No. 109A

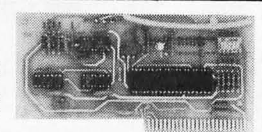


DISKETTES



Box of 10, 5" $29.95, 8" $39.95.
Plastic box, holds 10 diskettes, 5" - $4.50, 8" - $6.50.

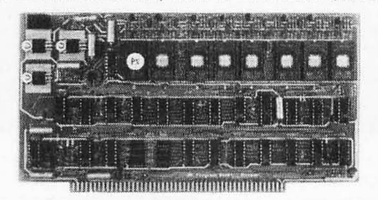
APPLE II SERIAL I/O INTERFACE



Baud rate is continuously adjustable from 0 to 30,000 • Plugs into any peripheral connector • Low current drain. RS-232 input and output • On board switch selectable 5 to 8 data bits, 1 or 2 stop bits, and parity or no parity either odd or even • Jumper selectable address • SOFTWARE • Input and Output routine from monitor or BASIC to teletype or other serial printer • Program for using an Apple II for a video or an intelligent terminal. Also can output in correspondence code to interface with some selectrics. • Also watches DTR • Board only $15.00 Part No. 2, with parts $42.00 Part No. 2A, assembled $62.00 Part No. 2C

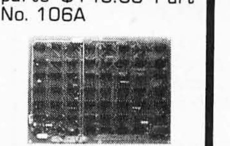
8K EPROM PIICEON

Saves programs on PROM permanently (until erased via UV light) up to 8K bytes. Programs may be directly run from the program saver such as fixed routines or assemblers. • S-100 bus compatible • Room for 8K bytes of EPROM non-volatile memory (2708's). • On-board PROM programming • Address relocation of each 4K of memory to any 4K boundary within 64K • Power on jump and reset jump option for "turnkey" systems and computers without a front panel • Program saver software available • Solder mask both sides • Full silkscreen for easy assembly. Program saver software in 1 2708 EPROM $25. Bare board $35 including custom coil, board with parts but no EPROMS $139, with 4 EPROMS $179, with 8 EPROMS $219.



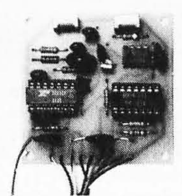
T.V. TYPEWRITER

• Stand alone TVT • 32 char/line, 16 lines, modifications for 64 char/line included • Parallel ASCII (TTL) input • Video output • 1K on board memory • Output for computer controlled curser • Auto scroll • Non-destructive curser • Curser inputs: up, down, left, right, home, EOL, EOS • Scroll up, down • Requires +5 volts at 1.5 amps, and -12 volts at 30 mA • All 7400, TTL chips • Char. gen. 2513 • Upper case only • Board only $39.00 Part No. 106, with parts $145.00 Part No. 106A



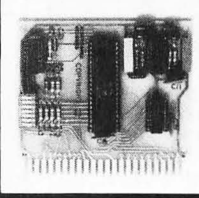
TAPE INTERFACE

• Play and record Kansas City Standard tapes • Converts a low cost tape recorder to a digital recorder • Works up to 1200 baud • Digital in and out are TTL-serial • Output of board connects to mic. in of recorder • Earphone of recorder connects to input on board • No coils • Requires +5 volts, low power drain • Board only $7.60 Part No. 111, with parts $27.50 Part No. 111A



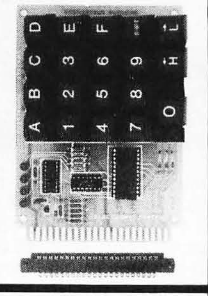
UART & BAUD RATE GENERATOR

• Converts serial to parallel and parallel to serial • Low cost on board baud rate generator • Baud rates: 110, 150, 300, 600, 1200, and 2400 • Low power drain +5 volts and -12 volts required • TTL compatible • All characters contain a start bit, 5 to 8 data bits, 1 or 2 stop bits, and either odd or even parity. • All connections go to a 44 pin gold plated edge connector • Board only $12.00 Part No. 101, with parts $35.00 Part No. 101A, 44 pin edge connector $4.00 Part No. 44P



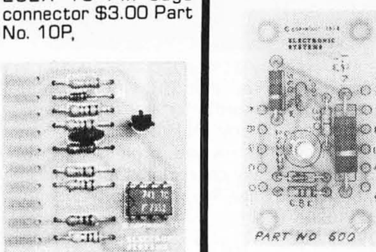
HEX ENCODED KEYBOARD E.S.

This HEX keyboard has 19 keys, 16 encoded with 3 user definable. The encoded TTL outputs, 8-4-2-1 and STROBE are debounced and available in true and complement form. Four onboard LEDs indicate the HEX code generated for each key depression. The board requires a single +5 volt supply. Board only $15.00 Part No. HEX-3, with parts $49.95 Part No. HEX-3A. 44 pin edge connector $4.00 Part No. 44P.



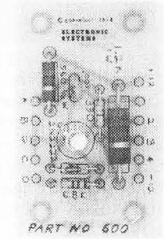
RS-232/ TTL INTERFACE

• Converts TTL to RS-232, and converts RS-232 to TTL • Two separate circuits • Requires -12 and +12 volts • All connections go to a 10 pin gold plated edge connector, kit $ 9.95 Part No. 232A 10 Pin edge connector $3.00 Part No. 10P.



RS-232/TTY INTERFACE

This board has two active circuits, one converts RS-232 to 20mA, and the other converts 20mA to RS-232. Requires +12 and -12 volts. $9.95 Part No. 600A Kit.



WAMECO PRODUCTS WITH ELECTRONIC SYSTEMS PARTS

FDC-1 FLOPPY CONTROLLER BOARD will drive shugart, pertek, remex 5" & 8" drives up to 8 drives, on board PROM with power boot up, will operate with CPM (not included). PCBD $42.95
FPB-1 Front Panel. (Finally) IMSAI size hex displays. Byte or instruction single step. PCBD $42.95
MEM-1A 8Kx8 fully buffered, S-100, uses 2102 type RAMS. PCBD .... $24.95, $168 Kit
QMB-12 MOTHER BOARD, 13 slot, terminated, S-100 board only .... $34.95 $89.95 Kit
CPU-1 8080A Processor board S-100 with 8 level vector interrupt PCBD .. $25.95 $89.95 Kit
RTC-1 Realtime clock board. Two independent interrupts. Software programmable. PCBD .... $25.95, $60.95 Kit
EPM-1 1702A 4K EPROM card PCBD .... $25.95 $49.95 with parts less EPROMS
EPM-2 2708/2716 16K/32K EPROM card PCBD .... $24.95 $49.95 with parts less EPROMS
QMB-9 MOTHER BOARD. Short Version of QMB-12. 9 Slots PCBD .... $30.95 $67.95 Kit
MEM-2 16Kx8 Fully Buffered 2114 Board PCBD .... $25.95, $269.95 Kit

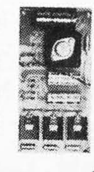
S-100 BUS ACTIVE TERMINATOR

Board only $14.95 Part No. 900, with parts $24.95 Part No. 900A



DC POWER SUPPLY

• Board supplies a regulated +5 volts at 3 amps., +12, -12, and -5 volts at 1 amp. • Power required is 8 volts AC at 3 amps., and 24 volts AC C.T. at 1.5 amps. • Board only $12.50 Part No. 6085, with parts excluding transformers $42.50 Part No. 6085A



To Order: Mention part no. description, and price. In USA shipping paid by us for orders accompanied by check or money order. We accept C.O.D. orders in the U. S. only, or a VISA or Master Charge no., expiration date, signature, phone no., shipping charges will be added. CA residents add 6.5% for tax. Outside USA add 10% for air mail postage and handling. Payment must be in U. S. dollars. Dealer inquiries invited. 24 hour order line (408) 448-0800



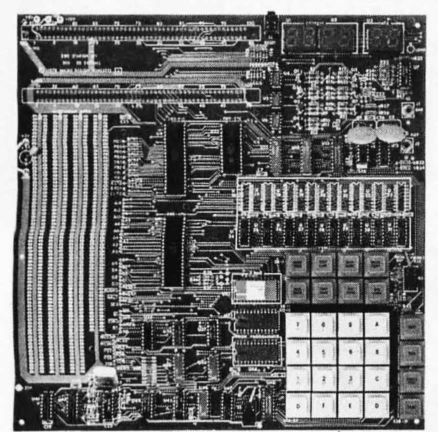
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Circle 208 on inquiry card.

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COMPLETE Z-80 MICROCOMPUTER



On-board keyboard, display, EPROM programmer, and cassette interface
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Wire-wrap area and room for 2 S-100 connectors
Two 8-bit parallel I/O ports, 4-channel CTC, 5 programmable breakpoints
Examine and change memory, I/O ports, or register

CPS-30010K (KIT) **$219.00**
CPS-30010A (A&T) **$365.00**

CP/M 2.0

Digital Research has done it again! This new release of their industry standard disk operating system is bound to be an even bigger hit than the original version. All of the fundamental file-size restrictions of release 1 have been eliminated, while maintaining full compatibility with the earlier versions. This new release can be field-configured by the user for a single mini-disk up through a multiple drive hard-disk system with 128 megabyte capacity. Field configuration can be accomplished easily through use of the Macro Library (DISKDEF) provided with CP/M 2.0.

A powerful operating system for only ... $150.00

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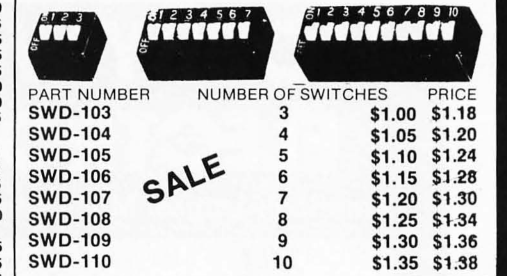
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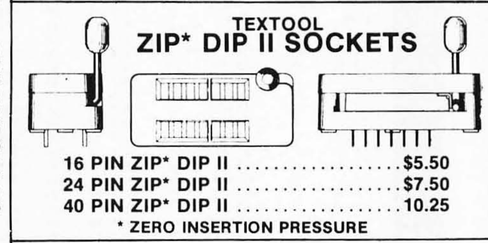
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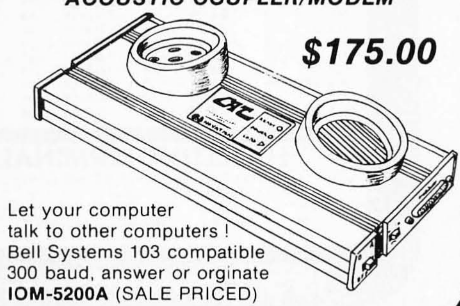
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BAUDOT Character Set: *A B C D E F G H I J K L M N O P Q R S T U V W X Y Z - ? : * 3 $ # ( ) . , 9 0 1 4 ! 5 7 ; 2 / 6 8* • **Cursor Modes:** *Home, Backspace, Horizontal Tab, Line Feed, Vertical Tab, Carriage Return. Two special cursor sequences are provided for absolute and relative X-Y cursor addressing* • **Cursor Control:** *Erase, End of Line, Erase of Screen, Form Feed, Delete* • **Monitor Operation:** *50 or 60Hz (jumper selectable.*

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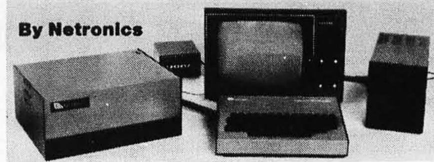
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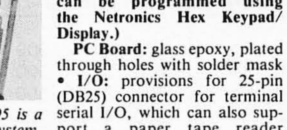
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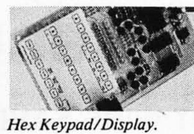


Level "A" at $129.95 is a complete operating system, perfect for beginners, hobbiests, or industrial controller use.

PC Board: glass epoxy, plated through holes with solder mask • **I/O:** provisions for 25-pin (DB25) connector for terminal serial I/O, which can also support a paper tape reader ...provision for 24-pin DIP socket for hex keyboard/display...cassette tape recorder input...cassette tape recorder output...cassette tape control output...speaker output... LED output indicator on SOD (serial output) line...printer interface (less drivers)...total of four 8-bit plus one 6-bit I/O ports • **Crystal Frequency:** 6.144 MHz • **Control Switches:** reset and user (RST 7.5) interrupt...additional provisions for RST 5.5, 6.5 and TRAP interrupts onboard • **Counter/Timer:** programmable, 14-bit binary • **System RAM:** 256 bytes located at F800, ideal for smaller systems and for use as an isolated stack area in expanded systems...RAM expandable to 64k via S-100 bus or 4K on motherboard.

System Monitor (Terminal Version): 2k bytes of deluxe system monitor ROM located at F000 leaving 0000 free for user RAM/ROM. Features include tape load with labeling ...tape dump with labeling...examine/change contents of memory ...insert data...warm start...examine and change all registers...single step with register display at each break point, a debugging/training feature...go to execution address... move blocks of memory from one location to another...fill blocks of memory with a constant...display blocks of memory ...automatic baud rate selection...variable display line length control (1-255 characters/line)...channelized I/O monitor routine with 8-bit parallel output for high speed printer... serial console in and console out channel so that monitor can communicate with I/O ports.

System Monitor (Hex Version): Tape load with labeling... tape dump with labeling...examine/change contents of memory...insert data...warm start...examine and change all registers...single step with register display at each break point ...go to execution address. Level "A" in the *Hex Version* makes a perfect controller for industrial applications and can be programmed using the Netronics Hex Keypad/Display.



Hex Keypad/Display.

Hex Keypad/Display Specifications

Calculator type keypad with 24 system defined and 16 user defined keys. 6 digit calculator type display which displays full address plus data as well as register and status information.

Level "B" Specifications

Level "B" provides the S-100 signals plus buffers/drivers to support up to six S-100 bus boards and includes: address decoding for onboard 4k RAM expansion select-able in 4k blocks...address decoding for onboard 8k EPROM expansion selectable in 8k blocks...address and data bus drivers for onboard expansion...wait state generator (jumper selectable), to allow the use of slower memories...two separate 5 volt regulators.



Explorer/85 with Level "C" card cage.

Level "C" Specifications

Level "C" expands Explorer's motherboard with a card cage, allowing you to plug up to six S-100 cards directly into the motherboard. Both cage and cards are neatly contained inside Explorer's deluxe steel cabinet. Level "C" includes a sheet metal superstructure, a 5-card gold plated S-100 extension PC board which plugs into the motherboard. Just add required number of S-100 connectors

Level "D" Specifications

Level "D" provides 4k or RAM, power supply regulation, filtering decoupling components and sockets to expand your Explorer/85 memory to 4k (plus the original 256 bytes located in the 8155A). The static RAM can be located anywhere from 0000 to EFFF in 4k blocks.

Level "E" Specifications

Level "E" adds sockets for 8k of EPROM to use the popular Intel 2716 or the TI 2516. It includes all sockets, power supply regulator, heat sink, filtering and decoupling components. Sockets may also be used for soon to be available RAM IC's (allowing for up to 12k of onboard RAM).

Order A Coordinated Explorer/85 Applications Pak!

Experimenter's Pak (SAVE $12.50)—Buy Level "A" and Hex Keypad/Display for **$199.90** and get FREE Intel 8085 user's manual plus FREE postage & handling!

Student Pak (SAVE $24.45)—Buy Level "A," ASCII Keyboard/Computer Terminal, and Power Supply for **$319.85** and get FREE RF Modulator plus FREE Intel 8085 user's manual plus FREE postage & handling!

Engineering Pak (SAVE $41.00)—Buy Levels "A," "B," "C," "D," and "E" with Power Supply, ASCII Keyboard/Computer Terminal, and six S-100 Bus Connectors for **$514.75** and get 10 FREE computer grade cassette tapes plus FREE 8085 user's manual plus FREE postage & handling!

Business Pak (SAVE $89.95)—Buy Explorer/85 Levels "A," "B," and "C" (with cabinet), Power Supply, ASCII Keyboard/Computer Terminal (with cabinet), 16k RAM, 12" Video Monitor, North Star 5-1/4" Disk Drive (includes North Star BASIC) with power supply and cabinet, all for just **$1599.40** and get 10 FREE 5-1/4" minidiskettes ($49.95 value) plus FREE 8085 user's manual plus FREE postage & handling!

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Please send the items checked below—

☐ **Explorer/85 Level "A" Kit** (ASCII Version), **$129.95** plus $3 p&h.
☐ **Explorer/85 Level "A" Kit** (Hex Version), **$129.95** plus $3 p&h.
☐ **8k Microsoft BASIC** on cassette tape, **$64.95** postpaid.
☐ **8k Microsoft BASIC in ROM Kit** (requires Levels "B," "D," and "E"), **$99.95** plus $2 p&h.
☐ **Level "B" (S-100) Kit, $49.95** plus $2 p&h.
☐ **Level "C" (S-100 6-card expander) Kit, $39.95** plus $2 p&h.
☐ **Level "D" (4k RAM) Kit, $69.95** plus $2 p&h.
☐ **Level "E" (EPROM/ROM) Kit, $5.95** plus 50¢ p&h.
☐ **Deluxe Steel Cabinet** for Explorer/85, **$49.95** plus $3 p&h.
☐ **ASCII Keyboard/Computer Terminal Kit** (features a full 128 character set, upper & lower case, full cursor control, 75 ohm video output convertible to baudot output, selectable baud rate, RS232-C or 20 ma. I/O, 32 or 64 character by 16 line formats, and can be used with either a CRT monitor or a TV set (if you have an RF modulator), **$149.95** plus $2.50 p&h.
☐ **Hex Keypad/Display Kit, $69.95** plus $2 p&h.
☐ **Deluxe Steel Cabinet** for ASCII Keyboard/Terminal, **$19.95** plus $2.50 p&h.
☐ **Power Supply Kit** (±8V @ 5 amps) in deluxe steel cabinet, **$39.95** plus $2 p&h.
☐ **Gold Plated S-100 Bus Connectors, $4.85** each, postpaid.
☐ **RF Modulator Kit** (allows you to use your TV set as a monitor), **$8.95** postpaid.
☐ **16k RAM Kit** (S-100 Board expands to 64k), **$199.95** plus $2 p&h.
☐ **32k RAM Kit, $329.95** plus $2 p&h.
☐ **48K RAM Kit, $459.95** plus $2 p&h.
☐ **64k RAM Kit, $589.95** plus $2 p&h.
☐ **16k RAM Expansion Kit** (to expand any of the above up to 64k), **$139.95** plus $2 p&h each.
☐ **Intel 8085 cpu User's Manual, $7.50** postpaid.
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☐ **12" Video Monitor** (10 MHz bandwidth), **$139.95** plus $5 p&h.
☐ **North Star Double Density Floppy Disk Kit** (One Drive) for Explorer/85 (includes 3 drive S-100 controller, DOS, and extended BASIC with personalized disk operating system—just plug it in and you're up and running!), **$699.95** plus $5 p&h.
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Circle 215 on inquiry card.

Circle 238 on inquiry card.

page

Precut Wire Wrap Wire

PRECUT WIRE SAVES TIME AND COSTS LESS THAN WIRE ON SPOOLS

Kynar precut wire. All lengths are overall, including 1" strip on each end. Colors and lengths cannot be mixed for quantity pricing. All sizes listed are in stock for immediate shipment. Other lengths available. Choose from colors: Red, Blue, Yellow, Orange, Black, White, Green and Violet. One inch tubes are available at 50¢. State second choice on colors when possible.

Length	100	500	1,000	Length	100	500	1,000
2.5 inches	1.04	2.98	5.16	6.5 inches	1.60	5.37	9.84
3	1.08	3.22	5.65	7	1.66	5.63	10.37
3.5	1.13	3.46	6.14	7.5	1.73	5.89	10.91
4	1.18	3.70	6.62	8	1.78	6.15	11.44
4.5	1.23	3.95	7.12	8.5	1.82	6.41	11.97
5	1.28	4.20	7.61	9	1.87	6.76	12.51
5.5	1.32	4.48	8.10	9.5	1.92	6.93	13.04
6	1.37	4.72	8.59	10	1.99	7.26	13.57

Kit #1 $7.95 Less than 2.7¢/ft. (#30)	Kit #2 $19.95 Less than 2¢/ft. (#30)	KIT #3 $24.95 Less than 1.7¢/ft. (#30)	Kit #4 $44.95 Less than 1.6¢/ft. (#30)	#30 Spools 1-4 5-9 10+
250 3" 100 4"	250 2½" 250 5"	500 2½" 500 4½"	1000 2½" 1000 4½"	50 ft. 1.75 1.60 1.40
250 3" 100 5"	500 3" 100 5½"	500 3" 500 5"	1000 3" 1000 5"	100 ft. 3.00 2.75 2.50
100 4" 100 6"	500 3½" 250 6"	500 3½" 500 5½"	1000 3½" 1000 5"	250 ft. 4.75 4.50 4.25
	500 4" 100 6½"	500 4" 500 6"	1000 4" 1000 6"	500 ft. 8.50 8.00 7.50
	250 4½" 100 7"			1000 ft. 14.50 12.50 10.50

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BATTERY HOBBY TOOL*

- Auto Indexing
- Anti-Overwrapping
- Modified Wrap

BW2630	Tool	**$19.85**
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BC1	Batteries & Charger	**11.00**

*Requires 2 "C" Nicad Batteries

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$5 CREDIT TOWARD PURCHASE OF ANY WIRE KIT

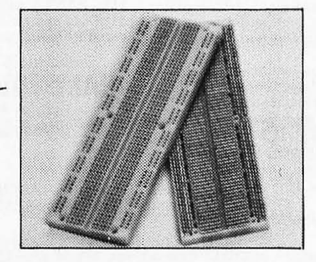
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Solderless Breadboarding

SK10 2/$25.00 ~~$16.50~~

The SK10's unique matrix configuration is embedded in a high temperature plastic molding. It gives you 64 pairs of 5 common spring contacts for principle circuit construction and a series of common buss strips (8) of 25 connections each.

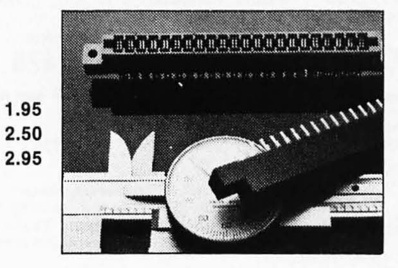
Dimensions: .33"h x 2.2"w x 6.5"l



TI Edge Card Connectors

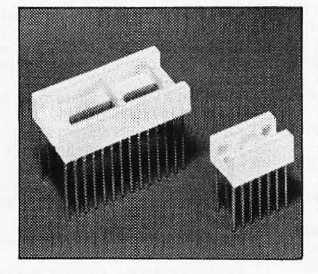
44 pin	ST	(.156" centers)	**1.95**
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All connectors gold plated.



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RN HIGH RELIABILITY eliminates trouble. "Side-wipe" contacts make 100% greater surface contact with the wide, flat sides of your IC leads for positive electrical connections.



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3-level Gold Closed Entry Design
All prices include Gold
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Sockets sold at these prices by the tube only.

Size	Quant./Tube	Price Ea.	Price/Tube
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16 pin	52	.34	$17.68
18 pin	23	.50	$11.50
20 pin	21	.65	$13.65
22 pin	19	.70	$13.30
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This quality dot matrix printer incorporates such features as software selectable character size to allow print densities upto 132 characters per line. Full forms handling capabilities and tractor feed mechansim adjustable to 9.5". The Paper Tiger is engineered to accept either parallel or RS232 serial ASCII. 110/220V.50/60Hz.

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8803-18
18 slot
IMSAI

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TELETYPE® MODEL 43

4320 KEYBOARD

TTL	AAA	$1050
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plus shipping

Minidisk Drive for TRS-80

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500	2.25	1.60	.85
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Edge Connectors

GOLD
100 PIN
IMSAI/ALTAIR

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SPECIALS		
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It's not offen that California Digital ventures into the distribution of consumer products, but we have resently come accross a product that appears so unique that we just had to add it to our product line. This is the System X-10 manufactured by the BSR turntable company. This space age system will remotely control any light or appliance in your home or office. Command signals are transmitted from the command console over your existing wiring. From your bed or easy chair you can control up to 16 different electrical devices inside and outside your home. Use the System X-10 to control your stereo, television or any light fixture on the premises.

The modular system is available in the following components:

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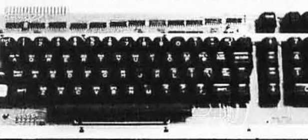
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The most cost effective way to store data processing information, when random recall is a prime factor. The SA800 is fully compatible with the IBM 3740 format. Write protect circuitry, low maintenance & Shugart quality.

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KEYTRONIC ASCII & ASCII complement.
*Ten key data pad
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TRS-80 / APPLE II $65

16k memory (8) 4116's

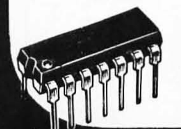
Installation is simple. Anyone who has ever changed a spark plug should be able to up-grade his microcomputer.

How can California Digital offer these memory up-grade sets at 25% below our competition? Simple, we buy in volume, wholesale to dealers and sell the balance directly to owners of personal microsystems. These 16K dynamic memory circuits are factory prime and unconditionally guaranteed for one full year. NOW, before you change your mind, pick up the telephone and order your up-grade memory from California Digital. Add $3 for TRS80 jumpers.

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2114 1Kx4 450	5.95	5.50	5.25	4.75	4.50
2114 1Kx4 300	8.95	8.50	8.00	*	*
4044 4Kx1 450	5.95	5.50	5.25	*	*
4044 4Kx1 250	9.95	9.50	9.00	*	*
4045 1Kx4 450	8.95	8.50	8.00	*	*
4045 1Kx4 250	9.95	9.50	9.00	*	*
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2716 TI		24.88	20.00	*
2532		85.00	*	*

Buying a CRT Terminal?

Hazeltine • Soroc • Lear Siegler

$850

Well if you really insist upon purchasing one of the above terminals, sure, we'll sell it to you. But when the keyboard starts to double bounce, the screen fades and the power supply just craps out don't call us, complain to the manufacturer.

The alternative, take a serious look at the ADDS Regent 25, we have, and concluded that this terminal offers, the best value in todays market. Through years of research the ADDS Company has evolved a low maintenance, extremely durable CRT terminal capable of withstanding an abusive 24 hour duty cycle. The Regent 25 features Intel 8085 microprocessor controlled circuitry along with the Cherry Switch long-life capacitance keyboard.

18 key cursor and numeric pad doubles to allow for user definable special functions. True descending lower case characters along with a fully addressable cursor makes the Regent 25 the ideal word processing terminal.

High-resolution screen is capable of displaying 96 upper and lower case ASCII characters and 32 control codes. This unique feature assist in the debugging of programs. The Regent 25 is switch selectable to display six European languages along with Katakana.

Clearly the Regent 25 is not your adverage terminal, but than, ADDS is not your adverage terminal company.

Regent® 25 from **APPLIED DIGITAL DATA SYSTEMS**

MINIATURE SWITCHES



your choice

$.98

10	50	100	1k
$.88	.81	.73	.66

SPDT Miniature Toggles

7101 C&K	ON-NONE-ON
7107 jbt	ON-OFF(mnt.ON)
7108 CK	ON-(moment ON)
7103 CK	ON OFF ON
Rotary	3P-4-Pos.
Rotary	3P-6-Pos.
Push B (N.O.)	$.39ea. 4/$1

DIP Switch

$1.29 ea.

10	25	100	1K
$1.19	1.09	.97	.83

specify 4, 7 or 8 pos.

SPST

$139.50



PORTABLE DATA ENTRY SYSTEM

These used data terminals were originally designed for chain store inventory control and order entry systems. The operator enters the inventory control number, merchandise on hand and the unit price. After all pertinent data has been entered into the recorder, the main warehouse is telephoned, the handset is placed in the acoustic coupler and all the recorded information is transmitted back to the master computer. With a little imagination and one of these portable entry systems, you should be able to exchange programs and computer information with associates across the country. All units were removed from service in working condition. Original cost $2,500. Each system comes complete with:

- Portable Cassette Drive Unit
- Removable Entry Keyboard with LED Display
- Five Gould "D" NiCads
- Acoustical Coupler
- Battery Charger
- DB25 Cable
- Shoulder starp
- Full Documentation

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500	1,000	11,000
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VISA



Circle 216 on inquiry card.

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		SN7472N	.29		
SN7400N	.16	SN7473N	.35	SN74160N	.89
SN7401N	.18	SN7474N	.35	SN74161N	.89
SN7402N	.18	SN7475N	.49	SN74162N	1.95
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SN7410N	.18	SN7489N	1.75	SN74173N	1.25
SN7411N	.25	SN7490N	.45	SN74174N	.89
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SN7413N	.40	SN7492N	.43	SN74176N	.79
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SN7417N	.25	SN7495N	.65	SN74180N	.79
SN7420N	.20	SN7496N	.65	SN74181N	1.95
SN7421N	.29	SN7497N	3.00	SN74182N	.79
SN7422N	.39	SN74100N	.89	SN74184N	1.95
SN7423N	.25	SN74107N	.35	SN74185N	1.95
SN7425N	.29	SN74109N	.59	SN74186N	9.95
SN7426N	.29	SN74116N	1.95	SN74188N	3.95
SN7427N	.25	SN74121N	.35	SN74190N	1.25
SN7429N	.39	SN74122N	.39	SN74191N	1.25
SN7430N	.20	SN74123N	.49	SN74192N	.79
SN7432N	.25	SN74125N	.49	SN74193N	.79
SN7437N	.25	SN74126N	.49	SN74194N	.89
SN7438N	.25	SN74132N	.75	SN74195N	.69
SN7439N	.25	SN74136N	.75	SN74196N	.89
SN7440N	.20	SN74141N	.79	SN74197N	.89
SN7441N	.89	SN74142N	2.95	SN74198N	1.49
SN7442N	.49	SN74143N	2.95	SN74199N	1.49
SN7443N	.75	SN74144N	2.95	SN74S200	4.95
SN7444N	.75	SN74145N	.79	SN74251N	.99
SN7445N	.75	SN74147N	1.95	SN74279N	.79
SN7446N	.69	SN74148N	1.29	SN74283N	2.25
SN7447N	.59	SN74150N	.89	SN74284N	3.95
SN7448N	.79	SN74151N	.59	SN74285N	3.95
SN7450N	.20	SN74152N	.59	SN74365N	.69
SN7451N	.20	SN74153N	.59	SN74366N	.69
SN7453N	.20	SN74154N	.99	SN74367N	.69
SN7454N	.20	SN74155N	.79	SN74368N	.69
SN7459A	.25	SN74156N	.79	SN74390N	1.95
SN7460N	.20	SN74157N	.65	SN74393N	1.95

C/MOS

CD4000	.23			CD4070	.55
CD4001	.23			CD4071	.23
CD4002	.23	CD4028	.89	CD4072	.49
CD4006	1.19	CD4029	1.19	CD4076	1.39
CD4007	.25	CD4030	.49	CD4081	.23
CD4009	.49	CD4035	.99	CD4082	.23
CD4010	.49	CD4040	1.19	CD4093	.99
CD4011	.23	CD4041	1.25	CD4098	2.49
CD4012	.25	CD4042	.99	MC14409	14.95
CD4013	.39	CD4043	.89	MC14410	14.95
CD4014	1.39	CD4044	.89	MC14411	14.95
CD4015	1.19	CD4046	1.79	MC14419	4.95
CD4016	.49	CD4047	2.50	MC14433	19.95
CD4017	1.19	CD4048	1.35	MC14506	.75
CD4018	.99	CD4049	.49	MC14507	.99
CD4019	.49	CD4050	.49	MC14562	14.50
CD4020	1.19	CD4051	1.19	MC14583	3.50
CD4021	1.39	CD4053	1.19	CD4508	3.95
CD4022	1.19	CD4056	2.95	CD4510	1.39
CD4023	.23	CD4059	9.95	CD4511	1.29
CD4024	.79	CD4060	1.49	CD4515	2.95
CD4025	.23	CD4066	.79	CD4518	1.29
CD4026	2.25	CD4068	.39	CD4520	1.29
CD4027	.69	CD4069	.45	CD4566	2.25

74C00

74C00	.39			74C163	2.49
74C02	.39			74C164	2.49
74C04	.39	74C85	2.49	74C173	2.60
74C08	.49	74C90	1.95	74C192	2.49
74C10	.39	74C93	1.95	74C193	2.49
74C14	1.95	74C95	1.95	74C195	2.49
74C20	.39	74C107	1.25	74C922	7.95
74C30	.39	74C151	2.90	74C923	6.25
74C42	1.95	74C154	3.00	74C925	8.95
74C48	2.49	74C157	2.15	74C926	8.95
74C73	.89	74C160	2.49	80C95	1.50
74C74	.89	74C161	2.49	80C97	1.50

LINEAR

78MG	1.75			LM710N	.79
LM106H	.99			LM711N	.39
LM300H	.80	LM340K-18	1.35	LM723N/H	.55
LM301CN/H	.35	LM340K-24	1.35	LM733N	1.00
LM302H	.75	LM340T-5	1.25	LM739N	1.19
LM304H	1.00	LM340T-6	1.25	LM741CN/H	.35
LM305H	.60	LM340T-8	1.25	LM741-14N	.39
LM307CN/H	.35	LM340T-12	1.25	LM747N/H	.79
LM308CN/H	1.00	LM340T-15	1.25	LM748N/H	.39
LM309H	1.10	LM340T-18	1.25	LM1310N	1.95
LM309K	1.25	LM340T-24	1.25	LM1458CN/H	.59
LM310CN	1.15	LM358N	1.00	MC1488N	1.95
LM311N/H	.90	LM370N	1.95	MC1489N	1.95
LM312H	1.95	LM373N	3.25	LM1496N	.95
LM317K	6.50	LM377N	4.00	LM1556V	1.75
LM318CN/H	1.50	LM380N	1.25	MC1741SCP	3.00
LM319N	1.30	LM380CN	.99	LM2111N	1.95
LM320K-5	1.35	LM381N	1.79	LM2901N	2.95
LM320K-5.2	1.35	LM382N	1.79	LM3053N	1.50
LM320K-12	1.35	NE501N	8.00	LM3065N	1.49
LM320K-15	1.35	NE510A	6.00	LM3900N(3401)	.59
LM320K-18	1.35	NE529A	4.95	LM3905N	1.49
LM320K-24	1.35	NE531H/V	3.95	LM3909N	1.25
LM320T-5	1.25	NE536T	6.00	MC5558V	.59
LM320T-5.2	1.25	NE540L	6.00	8038B	4.95
LM320T-8	1.25	NE544N	4.95	LM75450N	.49
LM320T-12	1.25	NE550N	1.30	75451CN	.39
LM320T-15	1.25	NE555V	.39	75452CN	.39
LM320T-18	1.25	NE556N	.99	75453CN	.39
LM320T-24	1.25	NE560B	5.00	75454CN	.39
LM323K-5	5.95	NE561B	5.00	75491CN	.79
LM324N	1.49	NE562B	5.00	75492CN	.89
LM339N	.99	NE565N/H	1.25	75493N	.89
LM340K-5	1.35	NE566CN	1.75	75494CN	.89
LM340K-6	1.35	NE567V/H	.99	RC4136	1.25
LM340K-8	1.35	NE570N	4.95	RC4151	3.95
LM340K-12	1.35	LM703CN/H	.69	RC4194	4.95
LM340K-15	1.35	LM709N/H	.29	RC4195	4.49

74LS00TTL

74LS00	.29			74LS138	.89
74LS01	.29			74LS139	.89
74LS02	.29	74LS47	.89	74LS151	.89
74LS03	.29	74LS51	.29	74LS155	.89
74LS04	.35	74LS54	.29	74LS157	.89
74LS05	.35	74LS55	.29	74LS160	1.15
74LS08	.29	74LS73	.45	74LS161	1.15
74LS09	.35	74LS74	.45	74LS162	1.25
74LS10	.29	74LS75	.59	74LS163	1.15
74LS11	.75	74LS76	.45	74LS164	1.25
74LS13	.59	74LS78	.49	74LS175	.99
74LS14	1.25	74LS83	.89	74LS181	2.49
74LS15	.35	74LS85	1.25	74LS190	1.15
74LS20	.29	74LS86	.45	74LS191	1.15
74LS21	.35	74LS90	.59	74LS192	1.15
74LS22	.35	74LS92	.75	74LS193	1.15
74LS26	.35	74LS93	.75	74LS194	1.15
74LS27	.35	74LS95	.99	74LS195	1.15
74LS28	.35	74LS96	1.15	74LS253	.99
74LS30	.29	74LS107	.45	74LS257	.89
74LS32	.35	74LS109	.45	74LS258	1.75
74LS37	.45	74LS112	.45	74LS260	.69
74LS40	.35	74LS123	1.25	74LS279	.75
74LS42	.89	74LS125	.89	74LS367	.75
		74LS132	.99	74LS368	.75
		74LS136	.49	74LS670	2.49

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incorporated

TU-ART Digital Interface

Cromemco's TU-ART digital interface is a convenient interface for CRT terminals, line printers, modems, and other devices. Has 2 serial I/O ports, 2 8-bit parallel I/O ports, and 10 independent programmable interval timers. Baud rates are software-selectable from 110-76,800 baud. Has vectored prioritized interrupts so it is able to support the powerful vectored interrupt structure of a Z-80 microprocessor. 10 interval timers w/real-time capability.

Serial I/O Ports:
No. of ports: 2
I/O levels: RS-232 or 20mA curr. loop
Low baud range: 110-9600 baud (software selectable)
High baud range: 880-76,800 baud (software selectable)
Parallel I/O Ports:
No. of ports: 2 Input ports: 8 bits
Output ports: 8 bits
Input load: one TTL equivalent
Output Drive: 20 TTL loads

Interval Timers:
No. of timers: 10
Timer range: 0-16.32 msec (software selectable)
Timer resolution: 64 microseconds
Vectored Interrupts:
No. restart locations (8080 mode): 8
No. restart locs. (Z-80 mode): 65,536
Prioritization of TU-ART ports: internally prioritized
Prioritization for multiple TU-ARTs: daisy-chaining

General Information:
UART Type: 5501 Bus: S-100
Power requirements: +8V @ 1.0A
+18V @ 80mA -18V @ 40mA
Operating environment: 0-55°C

TRT-W (Assembled) $295.00

DISCRETE LEDS

.200" dia.			.125" dia.		
XC556R	red	5/$1	XC209R	red	5/$1
XC556G	green	4/$1	XC209G	green	4/$1
XC556Y	yellow	4/$1	XC209Y	yellow	4/$1
XC556C	clear	4/$1			
.200" dia.			.185" dia.		
XC22R	red	5/$1	XC526R	red	5/$1
XC22G	green	4/$1	XC526G	green	4/$1
XC22Y	yellow	4/$1	XC526Y	yellow	4/$1
.170" dia.			XC526C	clear	4/$1
MV10B	red	4/$1	.190" dia.		
.085" dia.			XC111R	red	5/$1
MV50	red	6/$1	XC111G	green	4/$1
			XC111Y	yellow	4/$1
			XC111C	clear	4/$1

INFRA-RED LED
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T1001-Transmissive $7.95
T1001A-Reflective 8.25

DISPLAY LEDS

TYPE	POLARITY	HT	PRICE	TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode-red	.270	2.95	MAN 6730	Common Anode-red ± 1	.560	.99
MAN 2	5 x 7 Dot Matrix-red	.300	4.95	MAN 6740	Common Cathode-red-D.D.	.560	.99
MAN 3	Common Cathode-red	.125	.25	MAN 6750	Common Cathode-red ± 1	.560	.99
MAN 4	Common Cathode-red	.187	1.95	MAN 6760	Common Anode-red	.560	.99
MAN 7G	Common Anode-green	.300	1.25	MAN 6780	Common Cathode-red	.560	.99
MAN 7Y	Common Anode-yellow	.300	.99	DL701	Common Anode-red ± 1	.300	.99
MAN 72	Common Anode-red	.300	.75	DL704	Common Cathode-red	.300	.99
MAN 74	Common Cathode-red	.300	1.25	DL707	Common Anode-red	.300	.99
MAN 82	Common Anode-yellow	.300	.49	DL728	Common Cathode-red	.500	1.49
MAN 84	Common Cathode-yellow	.300	.99	DL741	Common Anode-red	.600	1.25
MAN 3620	Common Anode-orange	.300	.49	DL746	Common Anode-red ± 1	.630	1.49
MAN 3630	Common Anode-orange ± 1	.300	.99	DL747	Common Anode-red	.600	1.49
MAN 3640	Common Cathode-orange	.300	.99	DL749	Common Cathode-red ± 1	.630	1.49
MAN 4610	Common Anode-orange	.300	.99	DL750	Common Cathode-red	.600	1.49
MAN 4640	Common Cathode-orange	.400	.99	DL33B	Common Cathode-red	.110	.35
MAN 4710	Common Anode-red	.400	.99	FND70	Common Cathode	.250	.69
MAN 4730	Common Anode-red ± 1	.400	.99	FND358	Common Cathode ± 1	.357	.99
MAN 4740	Common Cathode-red	.400	.99	FND359	Common Cathode	.357	.75
MAN 4810	Common Anode-yellow	.400	.99	FND503	Common Cathode(FND500)	.500	.99
MAN 4840	Common Cathode-yellow	.400	.99	FND507	Common Anode (FND510)	.500	.99
MAN 6610	Common Anode-orange-D.D.	.560	.99	5082-7730	Common Anode-red	.300	.99
MAN 6630	Common Anode-orange ± 1	.560	.99	HDSP-3400	Common Anode-red	.800	1.50
MAN 6640	Common Cathode-orange-D.D.	.560	.99	HDSP-3403	Common Cathode red	.800	1.50
MAN 6650	Common Cathode-orange ± 1	.560	.99	5082-7300	4 x 7 sgl. Digit-RHDP	.600	19.95
MAN 6660	Common Anode-orange	.560	.99	5082-7302	4 x 7 Sgl. Digit-LHDP	.600	19.95
MAN 6680	Common Cathode-orange	.560	.99	5082-7304	Overrange character, (±1)	.600	15.00
MAN 6710	Common Anode-red-D.D.	.560	.99	5082-7340	4 x 7 Sgl. Digit-Hexadecimal	.600	22.50

RCA LINEAR

CA3013T	2.15	CA3082N	2.00
CA2023T	2.56	CA3083N	1.60
CA3035T	2.48	CA3086N	.85
CA3039T	1.35	CA3089N	3.75
CA3046N	1.30	CA3130T	1.39
CA3059N	3.25	CA3140T	1.25
CA3060N	3.25	CA3160T	1.25
CA3080T	.85	CA3401N	.59
CA3081N	2.00	CA3600N	3.50

CALCULATOR CHIPS/DRIVERS

MM5725	$2.95
MM5738	2.95
DM8864	2.00
DM8865	1.00
DM8887	.75
DM8889	.75
9374 7 seg. C.A. LED driver	1.50

CLOCK CHIPS

MM5309	$4.95
MM5311	4.95
MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5387/1998A	4.95
CT7001	6.95

MOTOROLA

MC1408L7	$4.95
MC1408L8	5.75
MC1439L	2.95
MC3022P	2.95
MC3061P	3.50
MC4016(74416)	7.50
MC4024P	3.95
MC4040P	6.95
MC4044P	4.50

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin LP	.$17	.16	.15	22 pin LP	$ .37	.36	.35
14 pin LP	.20	.19	.18	24 pin LP	.38	.37	.36
16 pin LP	.22	.21	.20	28 pin LP	.45	.44	.43
18 pin LP	.29	.28	.27	36 pin LP	.60	.59	.58
20 pin LP	.34	.32	.30	40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

14 pin ST	$.27	.25	.24	28 pin ST	$ .99	.90	.81
16 pin ST	.30	.27	.25	36 pin ST	1.39	1.26	1.15
18 pin ST	.35	.32	.30	40 pin ST	1.59	1.45	1.30
24 pin ST	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)

8 pin SG	$.30	.27	.24	24 pin SG	$ .70	.63	.57
14 pin SG	.35	.32	.29	28 pin SG	1.10	1.00	.90
16 pin SG	.38	.35	.32	36 pin SG	1.65	1.40	1.26
18 pin SG	.52	.47	.43	40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

8 pin WW	$.39	.38	.31				
10 pin WW	.45	.41	.37	22 pin WW	$ .95	.85	.75
14 pin WW	.39	.38	.37	24 pin WW	1.05	.95	.85
16 pin WW	.43	.42	.41	28 pin WW	1.40	1.25	1.10
18 pin WW	.75	.68	.62	36 pin WW	1.59	1.45	1.30
20 pin WW	.85	.79	.72	40 pin WW	1.75	1.55	1.40

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ASST. 1	5 ea.	10 OHM / 27 OHM	12 OHM / 33 OHM	15 OHM / 39 OHM	18 OHM / 47 OHM	22 OHM / 56 OHM	50 PCS	$1.75
ASST. 2	5 ea.	68 OHM / 180 OHM	82 OHM / 220 OHM	100 OHM / 270 OHM	120 OHM / 330 OHM	150 OHM / 390 OHM	50 PCS	1.75
ASST. 3	5 ea.	470 OHM / 1.2K	560 OHM / 1.5K	680 OHM / 1.8K	820 OHM / 2.2K	1K / 2.7K	50 PCS	1.75
ASST. 4	5 ea.	3.3K / 8.2K	3.9K / 10K	4.7K / 12K	5.6K / 15K	6.8K / 18K	50 PCS	1.75
ASST. 5	5 ea.	22K / 56K	27K / 68K	33K / 82K	39K / 100K	47K / 120K	50 PCS	1.75
ASST. 6	5 ea.	150K / 390K	180K / 470K	220K / 560K	270K / 680K	330K / 820K	50 PCS	1.75
ASST. 7	5 ea.	1M / 2.7M	1.2M / 3.3M	1.5M / 3.9M	1.8M / 4.7M	2.2M / 5.6M	50 PCS	1.75

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$9.95 ea.**

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XR555	.39	XR1800	3.20	XR4136	1.25
XR556	.99	XR2206	4.40	XR4151	3.95
XR567CP	.99	XR2207	3.85	XR4194	4.95
XR567CT	1.25	XR2208	5.20	XR4202	3.60
XR1310P	1.95	XR2209	1.75	XR4212	2.05
XR1468CN	3.85	XR2211	5.25	XR4558	.75
XR1488	1.95	XR2212	4.35	XR4739	1.15
XR1489	1.95	XR2240	3.45	XR4741	1.47

DIODES

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
				1N4002	100 PIV	1 AMP	12/1.00
				1N4003	200 PIV	1 AMP	12/1.00
1N746	3.3	400m	4/1.00	1N4004	400 PIV	1 AMP	12/1.00
1N751	5.1	400m	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N754	6.8	400m	4/1.00	1N3600	50	200m	6/1.00
1N757	9.0	400m	4/1.00	1N4148	75	10m	15/1.00
1N759	12.0	400m	4/1.00	1N4154	35	10m	12/1.00
1N959	8.2	400m	4/1.00	1N4733	5.1	1w	28
1N965	15	400m	4/1.00	1N4734	5.6	1w	28
1N5232	5.6	500m	28	1N4735	6.2	1w	28
1N5234	6.2	500m	28	1N4736	6.8	1w	28
1N5235	6.8	500m	28	1N4738	8.2	1w	28
1N5236	7.5	500m	28	1N4742	12	1w	28
1N5242	12	500m	28	1N4744	15	1w	28
1N5245	15	500m	28	1N1183	50 PIV	35 AMP	1.60
1N456	25	40m	6/1.00	1N1184	100 PIV	35 AMP	1.70
1N458	150	7m	6/1.00	1N1185	150 PIV	35 AMP	1.70
1N485A	180	10m	5/1.00	1N1186	200 PIV	35 AMP	1.80
1N4001	50 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR(2N1849)	$1.95
C36M	35A @ 600V	SCR	1.95
2N2328	1.6A @ 300V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC.	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC.	1.95

TRANSISTORS

C106B1	.50			2N3904	4/1.00
MPSA05	.30	2N3055	.89	2N3905	4/1.00
MPSA06	5/1.00	MJE3055	1.00	2N3906	4/1.00
TIS97	6/1.00	2N3392	5/1.00	2N4013	3/1.00
TIS98	6/1.00	2N3398	5/1.00	2N4123	6/1.00
40409	1.75	PN3567	3/1.00	PN4249	4/1.00
40410	1.75	PN3568	4/1.00	PN4250	4/1.00
40673	1.75	PN3569	4/1.00	2N4400	4/1.00
2N918	4/1.00	MPS3638A	5/1.00	2N4401	4/1.00
2N2219A	2/1.00	MPS3702	5/1.00	2N4402	4/1.00
2N2221A	4/1.00	2N3704	5/1.00	2N4403	4/1.00
2N2222A	5/1.00	MPS3704	5/1.00	2N4409	5/1.00
PN2222 Plastic	7/1.00	2N3705	5/1.00	2N5086	4/1.00
2N2369A	4/1.00	MPS3705	5/1.00	2N5087	4/1.00
MPS2369	5/1.00	2N3706	5/1.00	2N5088	4/1.00
2N2484	4/1.00	MPS3706	5/1.00	2N5089	4/1.00
2N2906	4/1.00	2N3707	5/1.00	2N5129	5/1.00
2N2907	5/1.00	2N3711	5/1.00	PN5134	5/1.00
PN2907 Plastic	7/1.00	2N3724A	.65	PN5138	5/1.00
2N2925	5/1.00	2N3725A	1.00	2N5139	5/1.00
MJE2955	1.25	2N3772	2.25	2N5210	5/1.00
2N3053	2/1.00	2N3823	1.00	2N5449	3/1.00
		2N3903	5/1.00	2N5951	3/1.00

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50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-99	100-		1-9	10-99	100-
10 pf	.05	.04	.03	.001μF	.05	.04	.035
22 pf	.05	.04	.03	.0047μF	.05	.04	.035
47 pf	.05	.04	.03	.01μF	.05	.04	.035
100 pf	.05	.04	.03	.022μF	.06	.05	.04
220 pf	.05	.04	.03	.047μF	.06	.05	.04
470 pf	.05	.04	.035	.1μF	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/35V	.35	.31	.27
.22/35V	.28	.23	.17	3.3/25V	.35	.31	.27
.33/35V	.28	.23	.17	4.7/25V	.33	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.49	.45	.35
.68/35V	.28	.23	.17	15/25V	.75	.68	.59
1.0/35V	.28	.23	.17	22/6V	.75	.60	.50

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.14	.12	.09	1.0/16V	.15	.13	.10
4.7/25V	.15	.13	.10	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

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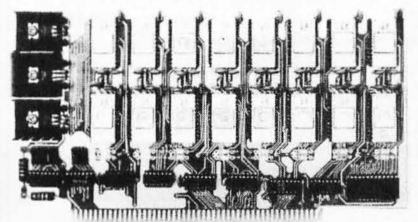
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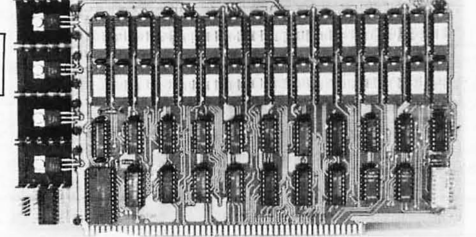
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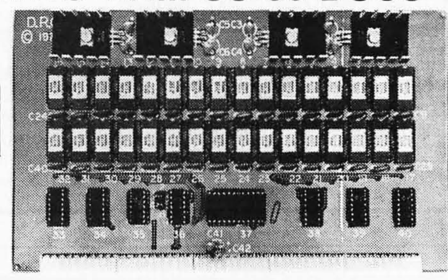
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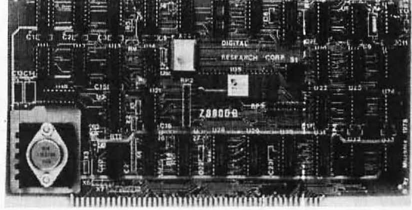
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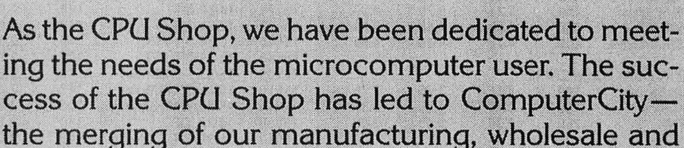
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ComputerCity Sampler

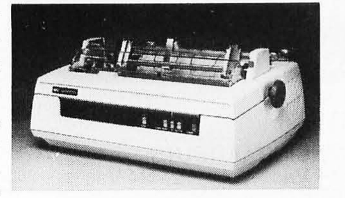
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10175	20/40 S/E TRS 80	.140	5.85	5.35	4.75
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15615	18/36 W/W	.200	3.60	3.20	2.90
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DA	15P	Male	2.35ea.	2.15ea.	2.00ea.
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DA	51226-1	2 pc. Black Hood	2.50ea.	2.25ea.	2.00ea.
DA	110963-2	2 pc. Grey Hood	1.60ea.	1.35ea.	1.30ea.
DB	25P	Male	2.80ea.	2.60ea.	2.40ea.
DB	25S	Female	3.60ea.	3.40ea.	3.20ea.
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DB	51226-1	2 pc. Black Hood	1.90ea.	1.65ea.	1.45ea.
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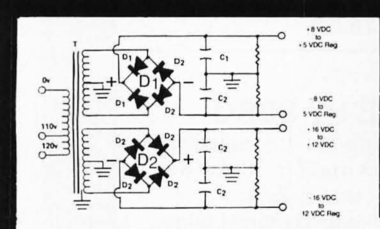
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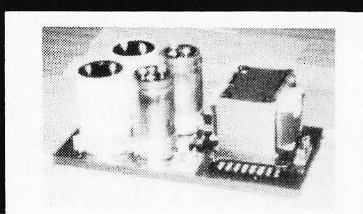
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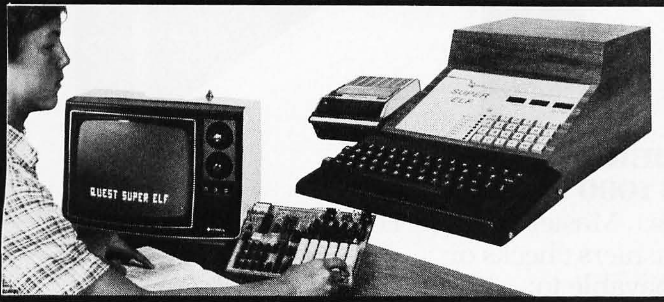
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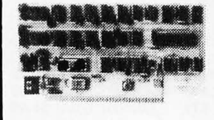
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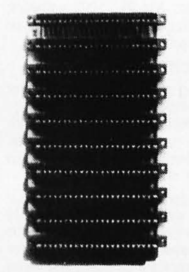
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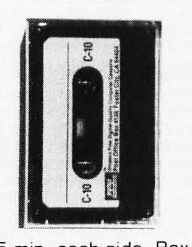
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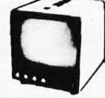
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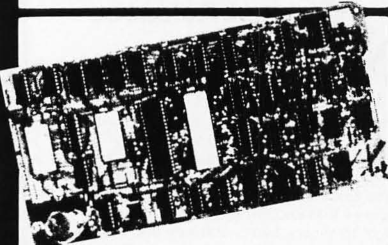
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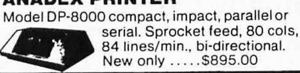
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FOR SALE: Assembled Heathkit H8, H9, and cassette recorder. Hardware includes 24 K memory and cassette interface. Software is Heath Extended BASIC, Assembler, Game Set 1, Biorhythm, and Space War. Included are reference manual and most of *REMarks(HUG magazine)* to date. Would cost nearly $1800 as a kit. The first check or money order for $1440 gets it. G Counsil, 1258 33 Av, San Francisco CA 94122, (415) 664-4508.

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October BOMB

"Picking Up The Pieces" (page 76) by Alfred S Baker won first place in the October 1979 BOMB. Second place was taken by Fred R Ruckdeschel's "Curve Fitting With Your Computer" (page 150). "Self-Refreshing LED Graphics Display"(page 58), by Steve Ciarcia, placed third. ■